# Appendix A
# ORIGEN2 Run ETR2

```
-1
-1
-1
  RDA     ORIGEN2, VERSION 2.1 (8-1-91) ETR A1 FUEL
  BAS     ONE 500 g ETR ELEMENT
  CUT     -1
  LIP     0 0 0
  LIB     0  1 2 3  204  908  909   9   50  0  4  0
  TIT     INITIAL COMPOSITIONS OF UNIT AMOUNTS OF FUEL AND STRUCT MAT'LS
  INP     -1   1  -1  -1  1  1
  MOV     -1   1   0   1.0
  HED      1                                                  500 g ELEMENT
  TIT     IRRADIATION OF ETR FUEL ELEMENT
  BUP
  IRP      50.0   2.826  1   2   3 2
  IRP     100.0   2.826  2   3   3 0
  IRP     200.0   2.826  3   4   3 0
  IRP     300.0   2.826  4   5   3 0
  IRP     400.0   2.826  5   6   3 0
  IRP     500.0   2.826  6   7   3 0
  IRP     600.0   2.826  7   8   3 0
  IRP     650.0   2.826  8   9   3 0
  BUP
  OPTL    8 8 8 8 8   8 5 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
  OPTA    8 8 8 8 5   8 5 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
  OPTF    8 8 8 8 5   8 5 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
  MOV      9    1    0   1.0
  DEC     1.6    1   2   5   4
  DEC     1.7    2   3   5   0
  DEC     1.8    3   4   5   0
  DEC     1.9    4   5   5   0
  DEC     2.0    5   6   5   0
  DEC     2.1    6   7   5   0
  DEC     2.2    7   8   5   0
  DEC     2.3    8   9   5   0
  OUT      -9    1     -1    0
  OUT       9    1     -1    0
  RDA     READ FUEL COMPOSITION
  END
  2   922340  5.793 922350   500. 922360  1.0858 922380  28.825 FUEL 93.3%
  0
```

Appendix A

```
echo off
echo **                                                                    **
echo **                              O R I G E N 2                         **
echo **                                                                    **
copy etr2.INP tape5.inp >nul
copy \origen2\libs\decay.lib+\origen2\libs\atr.lib tape9.inp >nul
copy \origen2\libs\gxuo2brm.lib tape10.inp >nul
\origen2\code\origen2
rem  combine and save files from run
copy tape12.out+tape6.out etr2.u6 >nul
copy tape13.out+tape11.out etr2.u11 >nul
ren tape7.out etr2.pch
ren tape15.out etr2.dbg
ren tape16.out etr2.vxs
ren tape50.out etr2.ech
rem  cleanup files
del tape*.inp
del tape*.out
del etr2.pch
del etr2.dbg
del etr2.vxs
del etr2.ech
del etr2.u11
echo ************************************************************************
echo ****************** O R I G E N 2 - Version 2.1 ************************
echo ********************** Execution Completed ****************************
echo ************************************************************************
echo on
```

**etr2.ci**
**ORIGEN2 V2.1 (8-1-91), Run on 10/06/04 at 12:29:23**

| | 650.0HR | 1.6YR | 1.7YR | 1.8YR | 1.9YR | 2.0YR | 2.1YR | 2.2YR | 2.3YR |
|---|---|---|---|---|---|---|---|---|---|
| TL207 | 4.115E-13 | 9.232E-10 | 9.470E-10 | 1.023E-09 | 1.125E-09 | 1.238E-09 | 1.359E-09 | 1.487E-09 | 1.620E-09 |
| TL208 | 1.080E-08 | 6.070E-07 | 6.381E-07 | 6.647E-07 | 6.905E-07 | 7.154E-07 | 7.395E-07 | 7.628E-07 | 7.853E-07 |
| TL209 | 6.263E-14 | 4.852E-13 | 4.926E-13 | 5.133E-13 | 5.384E-13 | 5.643E-13 | 5.905E-13 | 6.167E-13 | 6.430E-13 |
| PB209 | 2.901E-12 | 2.246E-11 | 2.280E-11 | 2.376E-11 | 2.492E-11 | 2.613E-11 | 2.734E-11 | 2.855E-11 | 2.977E-11 |
| PB210 | 5.123E-14 | 3.254E-12 | 3.827E-12 | 4.467E-12 | 5.178E-12 | 5.966E-12 | 6.833E-12 | 7.783E-12 | 8.821E-12 |
| PB211 | 4.126E-13 | 9.258E-10 | 9.497E-10 | 1.026E-09 | 1.128E-09 | 1.242E-09 | 1.363E-09 | 1.491E-09 | 1.624E-09 |
| PB212 | 2.996E-08 | 1.689E-06 | 1.776E-06 | 1.850E-06 | 1.922E-06 | 1.991E-06 | 2.058E-06 | 2.123E-06 | 2.185E-06 |
| PB214 | 2.467E-13 | 1.796E-10 | 1.983E-10 | 2.214E-10 | 2.459E-10 | 2.716E-10 | 2.987E-10 | 3.269E-10 | 3.565E-10 |
| BI210 | 2.666E-14 | 3.254E-12 | 3.710E-12 | 4.336E-12 | 5.033E-12 | 5.806E-12 | 6.657E-12 | 7.590E-12 | 8.610E-12 |
| BI211 | 4.126E-13 | 9.258E-10 | 9.497E-10 | 1.026E-09 | 1.128E-09 | 1.242E-09 | 1.363E-09 | 1.491E-09 | 1.624E-09 |
| BI212 | 3.006E-08 | 1.689E-06 | 1.776E-06 | 1.850E-06 | 1.922E-06 | 1.991E-06 | 2.058E-06 | 2.123E-06 | 2.186E-06 |
| BI213 | 2.899E-12 | 2.246E-11 | 2.280E-11 | 2.376E-11 | 2.492E-11 | 2.613E-11 | 2.734E-11 | 2.855E-11 | 2.977E-11 |
| BI214 | 2.467E-13 | 1.796E-10 | 1.983E-10 | 2.214E-10 | 2.459E-10 | 2.716E-10 | 2.987E-10 | 3.269E-10 | 3.565E-10 |
| PO210 | 7.794E-16 | 1.587E-12 | 1.899E-12 | 2.254E-12 | 2.661E-12 | 3.123E-12 | 3.644E-12 | 4.227E-12 | 4.876E-12 |
| PO211 | 1.155E-15 | 2.592E-12 | 2.659E-12 | 2.872E-12 | 3.158E-12 | 3.477E-12 | 3.817E-12 | 4.174E-12 | 4.548E-12 |
| PO212 | 1.926E-08 | 1.082E-06 | 1.138E-06 | 1.185E-06 | 1.231E-06 | 1.276E-06 | 1.319E-06 | 1.360E-06 | 1.400E-06 |
| PO213 | 2.837E-12 | 2.198E-11 | 2.231E-11 | 2.325E-11 | 2.439E-11 | 2.556E-11 | 2.675E-11 | 2.794E-11 | 2.913E-11 |
| PO214 | 6.558E-11 | 1.795E-10 | 1.982E-10 | 2.214E-10 | 2.458E-10 | 2.716E-10 | 2.986E-10 | 3.269E-10 | 3.565E-10 |
| PO215 | 4.082E-13 | 9.258E-10 | 9.497E-10 | 1.026E-09 | 1.128E-09 | 1.242E-09 | 1.363E-09 | 1.491E-09 | 1.624E-09 |
| PO216 | 3.166E-08 | 1.689E-06 | 1.776E-06 | 1.850E-06 | 1.921E-06 | 1.991E-06 | 2.058E-06 | 2.123E-06 | 2.185E-06 |
| PO218 | 2.468E-13 | 1.796E-10 | 1.983E-10 | 2.215E-10 | 2.459E-10 | 2.717E-10 | 2.987E-10 | 3.270E-10 | 3.566E-10 |
| AT217 | 2.899E-12 | 2.246E-11 | 2.280E-11 | 2.376E-11 | 2.492E-11 | 2.613E-11 | 2.734E-11 | 2.855E-11 | 2.977E-11 |
| RN218 | 6.533E-11 | 2.277E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 |
| RN219 | 4.082E-13 | 9.258E-10 | 9.497E-10 | 1.026E-09 | 1.128E-09 | 1.242E-09 | 1.363E-09 | 1.491E-09 | 1.624E-09 |
| RN220 | 3.166E-08 | 1.689E-06 | 1.776E-06 | 1.850E-06 | 1.921E-06 | 1.991E-06 | 2.058E-06 | 2.123E-06 | 2.185E-06 |
| RN222 | 2.467E-13 | 1.796E-10 | 1.983E-10 | 2.215E-10 | 2.459E-10 | 2.717E-10 | 2.987E-10 | 3.270E-10 | 3.566E-10 |
| FR221 | 2.899E-12 | 2.246E-11 | 2.280E-11 | 2.376E-11 | 2.492E-11 | 2.613E-11 | 2.734E-11 | 2.855E-11 | 2.977E-11 |
| FR223 | 4.053E-14 | 1.278E-11 | 1.424E-11 | 1.578E-11 | 1.739E-11 | 1.909E-11 | 2.087E-11 | 2.272E-11 | 2.466E-11 |
| RA222 | 6.533E-11 | 2.277E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 |
| RA223 | 4.082E-13 | 9.258E-10 | 9.497E-10 | 1.026E-09 | 1.128E-09 | 1.242E-09 | 1.363E-09 | 1.491E-09 | 1.624E-09 |
| RA224 | 3.166E-08 | 1.689E-06 | 1.776E-06 | 1.850E-06 | 1.921E-06 | 1.991E-06 | 2.058E-06 | 2.123E-06 | 2.185E-06 |
| RA225 | 9.164E-12 | 2.246E-11 | 2.309E-11 | 2.420E-11 | 2.539E-11 | 2.660E-11 | 2.782E-11 | 2.903E-11 | 3.025E-11 |
| RA226 | 3.619E-13 | 1.796E-10 | 2.017E-10 | 2.251E-10 | 2.497E-10 | 2.757E-10 | 3.029E-10 | 3.314E-10 | 3.612E-10 |
| RA228 | 6.282E-18 | 7.792E-15 | 8.742E-15 | 9.743E-15 | 1.079E-14 | 1.190E-14 | 1.305E-14 | 1.425E-14 | 1.550E-14 |
| AC225 | 2.899E-12 | 2.246E-11 | 2.280E-11 | 2.376E-11 | 2.492E-11 | 2.613E-11 | 2.734E-11 | 2.855E-11 | 2.977E-11 |
| AC227 | 2.936E-12 | 9.258E-10 | 1.032E-09 | 1.143E-09 | 1.260E-09 | 1.383E-09 | 1.512E-09 | 1.647E-09 | 1.787E-09 |
| AC228 | 2.467E-10 | 7.792E-15 | 8.742E-15 | 9.744E-15 | 1.080E-14 | 1.190E-14 | 1.305E-14 | 1.425E-14 | 1.550E-14 |
| TH226 | 6.533E-11 | 2.277E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 | 2.276E-19 |

**etr2.ci**
**ORIGEN2 V2.1 (8-1-91), Run on 10/06/04 at 12:29:23**

| | 650.0HR | 1.6YR | 1.7YR | 1.8YR | 1.9YR | 2.0YR | 2.1YR | 2.2YR | 2.3YR |
|---|---|---|---|---|---|---|---|---|---|
| TH227 | 1.254E-12 | 9.130E-10 | 9.598E-10 | 1.052E-09 | 1.160E-09 | 1.276E-09 | 1.399E-09 | 1.527E-09 | 1.661E-09 |
| TH228 | 4.603E-08 | 1.689E-06 | 1.765E-06 | 1.839E-06 | 1.910E-06 | 1.979E-06 | 2.046E-06 | 2.110E-06 | 2.172E-06 |
| TH229 | 3.255E-12 | 2.246E-11 | 2.367E-11 | 2.489E-11 | 2.610E-11 | 2.731E-11 | 2.853E-11 | 2.974E-11 | 3.096E-11 |
| TH230 | 2.199E-08 | 4.953E-07 | 5.249E-07 | 5.545E-07 | 5.841E-07 | 6.137E-07 | 6.433E-07 | 6.729E-07 | 7.024E-07 |
| TH231 | 4.044E-03 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 |
| TH232 | 2.334E-15 | 9.713E-14 | 1.031E-13 | 1.090E-13 | 1.149E-13 | 1.208E-13 | 1.268E-13 | 1.327E-13 | 1.386E-13 |
| TH234 | 5.167E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 |
| PA231 | 3.353E-09 | 3.321E-08 | 3.513E-08 | 3.705E-08 | 3.897E-08 | 4.089E-08 | 4.281E-08 | 4.473E-08 | 4.666E-08 |
| PA233 | 2.866E-05 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 |
| PA234M | 7.371E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 |
| PA234 | 2.053E-06 | 1.226E-08 | 1.226E-08 | 1.226E-08 | 1.226E-08 | 1.226E-08 | 1.226E-08 | 1.226E-08 | 1.226E-08 |
| U230 | 6.528E-11 | 2.275E-19 | 2.275E-19 | 2.275E-19 | 2.275E-19 | 2.275E-19 | 2.275E-19 | 2.275E-19 | 2.275E-19 |
| U232 | 3.683E-06 | 3.829E-06 | 3.834E-06 | 3.839E-06 | 3.844E-06 | 3.848E-06 | 3.853E-06 | 3.857E-06 | 3.861E-06 |
| U233 | 1.261E-07 | 1.281E-07 | 1.282E-07 | 1.284E-07 | 1.285E-07 | 1.286E-07 | 1.287E-07 | 1.288E-07 | 1.290E-07 |
| U234 | 3.287E-02 | 3.287E-02 | 3.287E-02 | 3.287E-02 | 3.287E-02 | 3.287E-02 | 3.287E-02 | 3.287E-02 | 3.287E-02 |
| U235 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 | 8.715E-04 |
| U236 | 1.201E-03 | 1.201E-03 | 1.201E-03 | 1.201E-03 | 1.201E-03 | 1.201E-03 | 1.201E-03 | 1.201E-03 | 1.201E-03 |
| U237 | 1.567E+04 | 3.336E-05 | 3.320E-05 | 3.304E-05 | 3.288E-05 | 3.273E-05 | 3.257E-05 | 3.241E-05 | 3.226E-05 |
| U238 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 | 9.433E-06 |
| U240 | 3.437E-01 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 |
| NP235 | 1.521E-06 | 5.469E-07 | 5.130E-07 | 4.813E-07 | 4.515E-07 | 4.235E-07 | 3.973E-07 | 3.727E-07 | 3.496E-07 |
| NP236 | 6.416E-10 | 6.416E-10 | 6.416E-10 | 6.416E-10 | 6.416E-10 | 6.416E-10 | 6.416E-10 | 6.416E-10 | 6.416E-10 |
| NP237 | 1.460E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 | 2.814E-04 |
| NP238 | 6.400E+02 | 3.223E-09 | 3.221E-09 | 3.220E-09 | 3.218E-09 | 3.217E-09 | 3.215E-09 | 3.214E-09 | 3.212E-09 |
| NP239 | 2.407E+04 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 |
| NP240M | 3.769E+01 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 | 1.741E-13 |
| PU236 | 1.159E-05 | 9.395E-06 | 9.169E-06 | 8.949E-06 | 8.734E-06 | 8.524E-06 | 8.319E-06 | 8.119E-06 | 7.924E-06 |
| PU237 | 8.276E-05 | 1.148E-08 | 6.588E-09 | 3.781E-09 | 2.170E-09 | 1.246E-09 | 7.150E-10 | 4.104E-10 | 2.355E-10 |
| PU238 | 9.307E-02 | 1.337E-01 | 1.336E-01 | 1.334E-01 | 1.333E-01 | 1.332E-01 | 1.331E-01 | 1.330E-01 | 1.329E-01 |
| PU239 | 3.187E-02 | 3.837E-02 | 3.837E-02 | 3.837E-02 | 3.837E-02 | 3.837E-02 | 3.837E-02 | 3.837E-02 | 3.837E-02 |
| PU240 | 1.024E-02 | 1.024E-02 | 1.024E-02 | 1.024E-02 | 1.024E-02 | 1.024E-02 | 1.024E-02 | 1.024E-02 | 1.024E-02 |
| PU241 | 1.469E+00 | 1.360E+00 | 1.353E+00 | 1.347E+00 | 1.340E+00 | 1.334E+00 | 1.328E+00 | 1.321E+00 | 1.315E+00 |
| PU242 | 2.046E-06 | 2.046E-06 | 2.046E-06 | 2.046E-06 | 2.046E-06 | 2.046E-06 | 2.046E-06 | 2.046E-06 | 2.046E-06 |
| PU243 | 2.425E+00 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 |
| PU244 | 1.743E-13 | 1.743E-13 | 1.743E-13 | 1.743E-13 | 1.743E-13 | 1.743E-13 | 1.743E-13 | 1.743E-13 | 1.743E-13 |
| PU246 | 1.103E-09 | 6.815E-26 | 6.815E-26 | 6.815E-26 | 6.815E-26 | 6.815E-26 | 6.815E-26 | 6.815E-26 | 6.815E-26 |
| AM241 | 3.978E-05 | 3.662E-03 | 3.879E-03 | 4.095E-03 | 4.310E-03 | 4.524E-03 | 4.736E-03 | 4.948E-03 | 5.158E-03 |
| AM242M | 6.492E-07 | 6.445E-07 | 6.442E-07 | 6.439E-07 | 6.436E-07 | 6.433E-07 | 6.430E-07 | 6.427E-07 | 6.424E-07 |

**etr2.ci**
**ORIGEN2 V2.1 (8-1-91), Run on 10/06/04 at 12:29:23**

| | 650.0HR | 1.6YR | 1.7YR | 1.8YR | 1.9YR | 2.0YR | 2.1YR | 2.2YR | 2.3YR |
|---|---|---|---|---|---|---|---|---|---|
| AM242 | 1.079E-01 | 6.413E-07 | 6.410E-07 | 6.407E-07 | 6.404E-07 | 6.401E-07 | 6.398E-07 | 6.395E-07 | 6.392E-07 |
| AM243 | 2.932E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 | 3.117E-06 |
| AM245 | 3.048E-06 | 1.152E-20 | 1.064E-20 | 9.830E-21 | 9.082E-21 | 8.391E-21 | 7.753E-21 | 7.163E-21 | 6.619E-21 |
| AM246 | 1.104E-09 | 6.826E-26 | 6.816E-26 | 6.816E-26 | 6.816E-26 | 6.816E-26 | 6.816E-26 | 6.816E-26 | 6.816E-26 |
| CM241 | 3.029E-10 | 3.932E-15 | 1.946E-15 | 9.630E-16 | 4.765E-16 | 2.358E-16 | 1.170E-16 | 5.807E-17 | 2.882E-17 |
| CM242 | 1.867E-03 | 1.871E-04 | 1.603E-04 | 1.374E-04 | 1.177E-04 | 1.009E-04 | 8.644E-05 | 7.409E-05 | 6.352E-05 |
| CM243 | 1.019E-07 | 9.802E-08 | 9.779E-08 | 9.755E-08 | 9.731E-08 | 9.708E-08 | 9.684E-08 | 9.660E-08 | 9.637E-08 |
| CM244 | 4.535E-05 | 4.319E-05 | 4.302E-05 | 4.286E-05 | 4.270E-05 | 4.253E-05 | 4.237E-05 | 4.221E-05 | 4.205E-05 |
| CM245 | 9.208E-10 | 9.212E-10 | 9.212E-10 | 9.212E-10 | 9.212E-10 | 9.212E-10 | 9.212E-10 | 9.212E-10 | 9.212E-10 |
| CM246 | 2.262E-11 | 2.263E-11 | 2.263E-11 | 2.263E-11 | 2.263E-11 | 2.263E-11 | 2.262E-11 | 2.262E-11 | 2.262E-11 |
| CM247 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 | 8.867E-18 |
| CM248 | 2.973E-18 | 2.973E-18 | 2.973E-18 | 2.973E-18 | 2.973E-18 | 2.973E-18 | 2.973E-18 | 2.973E-18 | 2.973E-18 |
| CM250 | 2.991E-27 | 2.991E-27 | 2.991E-27 | 2.991E-27 | 2.991E-27 | 2.991E-27 | 2.991E-27 | 2.991E-27 | 2.991E-27 |
| BK249 | 2.729E-15 | 7.939E-16 | 7.335E-16 | 6.777E-16 | 6.262E-16 | 5.786E-16 | 5.346E-16 | 4.939E-16 | 4.564E-16 |
| BK250 | 4.575E-14 | 4.187E-28 | 4.187E-28 | 4.187E-28 | 4.187E-28 | 4.187E-28 | 4.187E-28 | 4.187E-28 | 4.187E-28 |
| CF249 | 2.858E-20 | 5.072E-18 | 5.222E-18 | 5.360E-18 | 5.488E-18 | 5.606E-18 | 5.715E-18 | 5.815E-18 | 5.908E-18 |
| CF250 | 1.155E-17 | 1.179E-17 | 1.173E-17 | 1.167E-17 | 1.160E-17 | 1.154E-17 | 1.148E-17 | 1.142E-17 | 1.136E-17 |
| CF251 | 2.017E-20 | 2.018E-20 | 2.018E-20 | 2.018E-20 | 2.018E-20 | 2.018E-20 | 2.018E-20 | 2.018E-20 | 2.018E-20 |
| CF252 | 4.495E-19 | 3.003E-19 | 3.003E-19 | 3.003E-19 | 3.003E-19 | 3.003E-19 | 3.003E-19 | 3.003E-19 | 3.003E-19 |
| H 3 | 1.082E+00 | 9.889E-01 | 9.834E-01 | 9.779E-01 | 9.724E-01 | 9.670E-01 | 9.615E-01 | 9.562E-01 | 9.508E-01 |
| BE 10 | 6.835E-09 | 6.835E-09 | 6.835E-09 | 6.835E-09 | 6.835E-09 | 6.835E-09 | 6.835E-09 | 6.835E-09 | 6.835E-09 |
| C 14 | 2.757E-07 | 2.756E-07 | 2.756E-07 | 2.756E-07 | 2.756E-07 | 2.756E-07 | 2.756E-07 | 2.756E-07 | 2.756E-07 |
| SE 79 | 9.913E-04 | 9.917E-04 | 9.917E-04 | 9.917E-04 | 9.917E-04 | 9.917E-04 | 9.917E-04 | 9.917E-04 | 9.917E-04 |
| KR 81 | 3.437E-11 | 3.437E-11 | 3.437E-11 | 3.437E-11 | 3.437E-11 | 3.437E-11 | 3.437E-11 | 3.437E-11 | 3.437E-11 |
| KR 85 | 3.031E+01 | 2.761E+01 | 2.743E+01 | 2.725E+01 | 2.708E+01 | 2.690E+01 | 2.673E+01 | 2.656E+01 | 2.639E+01 |
| RB 86 | 9.799E+00 | 3.649E-09 | 9.393E-10 | 2.418E-10 | 6.226E-11 | 1.603E-11 | 4.126E-12 | 1.062E-12 | 2.735E-13 |
| RB 87 | 6.642E-08 | 6.661E-08 | 6.661E-08 | 6.661E-08 | 6.661E-08 | 6.661E-08 | 6.661E-08 | 6.661E-08 | 6.661E-08 |
| SR 89 | 3.510E+04 | 1.153E+01 | 6.985E+00 | 4.231E+00 | 2.563E+00 | 1.552E+00 | 9.402E-01 | 5.695E-01 | 3.450E-01 |
| SR 90 | 2.386E+02 | 2.297E+02 | 2.291E+02 | 2.286E+02 | 2.281E+02 | 2.275E+02 | 2.270E+02 | 2.264E+02 | 2.259E+02 |
| Y 90 | 2.182E+02 | 2.297E+02 | 2.292E+02 | 2.287E+02 | 2.281E+02 | 2.276E+02 | 2.270E+02 | 2.265E+02 | 2.260E+02 |
| Y 91 | 3.723E+04 | 3.762E+01 | 2.441E+01 | 1.583E+01 | 1.027E+01 | 6.663E+00 | 4.323E+00 | 2.804E+00 | 1.819E+00 |
| NB 92 | 2.690E-10 | 1.302E-27 | 1.302E-27 | 1.302E-27 | 1.302E-27 | 1.302E-27 | 1.302E-27 | 1.302E-27 | 1.302E-27 |
| ZR 93 | 5.006E-03 | 5.122E-03 | 5.122E-03 | 5.122E-03 | 5.122E-03 | 5.122E-03 | 5.122E-03 | 5.122E-03 | 5.122E-03 |
| NB 93M | 9.658E-06 | 3.899E-04 | 4.127E-04 | 4.353E-04 | 4.578E-04 | 4.802E-04 | 5.025E-04 | 5.247E-04 | 5.468E-04 |
| NB 94 | 5.310E-08 | 5.311E-08 | 5.311E-08 | 5.311E-08 | 5.311E-08 | 5.311E-08 | 5.311E-08 | 5.311E-08 | 5.311E-08 |
| ZR 95 | 3.851E+04 | 6.866E+01 | 4.623E+01 | 3.112E+01 | 2.095E+01 | 1.410E+01 | 9.495E+00 | 6.392E+00 | 4.303E+00 |
| NB 95 | 9.043E+03 | 1.518E+02 | 1.023E+02 | 6.893E+01 | 4.643E+01 | 3.127E+01 | 2.106E+01 | 1.418E+01 | 9.547E+00 |

**etr2.ci**
**ORIGEN2 V2.1 (8-1-91), Run on 10/06/04 at 12:29:23**

| | 650.0HR | 1.6YR | 1.7YR | 1.8YR | 1.9YR | 2.0YR | 2.1YR | 2.2YR | 2.3YR |
|---|---|---|---|---|---|---|---|---|---|
| NB 95M | 2.259E+02 | 5.094E-01 | 3.434E-01 | 2.312E-01 | 1.556E-01 | 1.048E-01 | 7.053E-02 | 4.748E-02 | 3.197E-02 |
| TC 98 | 1.357E-09 | 1.357E-09 | 1.357E-09 | 1.357E-09 | 1.357E-09 | 1.357E-09 | 1.357E-09 | 1.357E-09 | 1.357E-09 |
| TC 99 | 2.903E-02 | 3.442E-02 | 3.442E-02 | 3.442E-02 | 3.442E-02 | 3.442E-02 | 3.442E-02 | 3.442E-02 | 3.442E-02 |
| RH102 | 7.069E-05 | 4.822E-05 | 4.708E-05 | 4.597E-05 | 4.489E-05 | 4.383E-05 | 4.279E-05 | 4.178E-05 | 4.079E-05 |
| RU103 | 2.823E+04 | 9.385E-01 | 4.926E-01 | 2.586E-01 | 1.357E-01 | 7.126E-02 | 3.740E-02 | 1.963E-02 | 1.031E-02 |
| RH103M | 2.545E+04 | 8.460E-01 | 4.441E-01 | 2.331E-01 | 1.224E-01 | 6.424E-02 | 3.372E-02 | 1.770E-02 | 9.291E-03 |
| RU106 | 4.969E+02 | 1.654E+02 | 1.544E+02 | 1.441E+02 | 1.345E+02 | 1.256E+02 | 1.173E+02 | 1.095E+02 | 1.022E+02 |
| RH106 | 4.304E+03 | 1.654E+02 | 1.544E+02 | 1.441E+02 | 1.345E+02 | 1.256E+02 | 1.173E+02 | 1.095E+02 | 1.022E+02 |
| AG106 | 1.385E-11 | 2.784E-32 | 2.784E-32 | 2.784E-32 | 2.784E-32 | 2.784E-32 | 2.784E-32 | 2.784E-32 | 2.784E-32 |
| PD107 | 3.667E-05 | 3.671E-05 | 3.671E-05 | 3.671E-05 | 3.671E-05 | 3.671E-05 | 3.671E-05 | 3.671E-05 | 3.671E-05 |
| AG108 | 1.811E-03 | 2.828E-11 | 2.827E-11 | 2.825E-11 | 2.824E-11 | 2.822E-11 | 2.821E-11 | 2.819E-11 | 2.817E-11 |
| AG108M | 3.206E-10 | 3.178E-10 | 3.176E-10 | 3.174E-10 | 3.173E-10 | 3.171E-10 | 3.169E-10 | 3.167E-10 | 3.166E-10 |
| AG109M | 1.211E+03 | 4.311E-09 | 4.082E-09 | 3.865E-09 | 3.660E-09 | 3.466E-09 | 3.282E-09 | 3.108E-09 | 2.943E-09 |
| CD109 | 1.032E-08 | 4.311E-09 | 4.082E-09 | 3.865E-09 | 3.660E-09 | 3.466E-09 | 3.282E-09 | 3.108E-09 | 2.943E-09 |
| AG110 | 1.954E+02 | 9.086E-04 | 8.210E-04 | 7.419E-04 | 6.704E-04 | 6.058E-04 | 5.475E-04 | 4.947E-04 | 4.470E-04 |
| AG110M | 3.456E-01 | 6.831E-02 | 6.173E-02 | 5.578E-02 | 5.041E-02 | 4.555E-02 | 4.116E-02 | 3.720E-02 | 3.361E-02 |
| CD113M | 3.078E-02 | 2.872E-02 | 2.859E-02 | 2.845E-02 | 2.832E-02 | 2.818E-02 | 2.805E-02 | 2.792E-02 | 2.778E-02 |
| IN114 | 3.056E-04 | 6.158E-09 | 3.693E-09 | 2.215E-09 | 1.328E-09 | 7.966E-10 | 4.777E-10 | 2.865E-10 | 1.718E-10 |
| IN114M | 2.299E-05 | 6.435E-09 | 3.859E-09 | 2.314E-09 | 1.388E-09 | 8.323E-10 | 4.992E-10 | 2.994E-10 | 1.795E-10 |
| CD115M | 1.160E+01 | 1.317E-03 | 7.465E-04 | 4.231E-04 | 2.398E-04 | 1.359E-04 | 7.705E-05 | 4.368E-05 | 2.476E-05 |
| IN115 | 2.631E-14 | 3.360E-14 | 3.360E-14 | 3.360E-14 | 3.360E-14 | 3.360E-14 | 3.360E-14 | 3.360E-14 | 3.360E-14 |
| IN115M | 3.643E+02 | 9.256E-08 | 5.246E-08 | 2.974E-08 | 1.686E-08 | 9.554E-09 | 5.415E-09 | 3.070E-09 | 1.740E-09 |
| SN117M | 1.123E-02 | 3.082E-15 | 5.052E-16 | 8.311E-17 | 1.344E-17 | 1.689E-18 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| SN119M | 4.417E-01 | 8.459E-02 | 7.629E-02 | 6.880E-02 | 6.204E-02 | 5.595E-02 | 5.046E-02 | 4.551E-02 | 4.104E-02 |
| SN121M | 2.150E-04 | 2.102E-04 | 2.100E-04 | 2.097E-04 | 2.094E-04 | 2.091E-04 | 2.088E-04 | 2.085E-04 | 2.082E-04 |
| SN123 | 1.821E+01 | 7.915E-01 | 6.506E-01 | 5.348E-01 | 4.396E-01 | 3.614E-01 | 2.970E-01 | 2.442E-01 | 2.007E-01 |
| TE123 | 3.060E-17 | 4.230E-17 | 4.238E-17 | 4.244E-17 | 4.249E-17 | 4.253E-17 | 4.257E-17 | 4.259E-17 | 4.262E-17 |
| TE123M | 3.696E-04 | 1.252E-05 | 1.014E-05 | 8.204E-06 | 6.640E-06 | 5.374E-06 | 4.349E-06 | 3.520E-06 | 2.849E-06 |
| SB124 | 1.310E+00 | 1.564E-03 | 1.027E-03 | 6.743E-04 | 4.428E-04 | 2.908E-04 | 1.909E-04 | 1.254E-04 | 8.233E-05 |
| SN125 | 3.154E+02 | 1.778E-16 | 1.225E-17 | 3.568E-19 | 3.568E-19 | 3.568E-19 | 3.568E-19 | 3.568E-19 | 3.568E-19 |
| SB125 | 1.436E+01 | 1.166E+01 | 1.137E+01 | 1.109E+01 | 1.082E+01 | 1.055E+01 | 1.029E+01 | 1.003E+01 | 9.785E+00 |
| TE125M | 4.548E-01 | 2.845E+00 | 2.774E+00 | 2.706E+00 | 2.639E+00 | 2.574E+00 | 2.510E+00 | 2.448E+00 | 2.387E+00 |
| SN126 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 |
| SB126 | 1.983E+01 | 1.234E-04 | 1.235E-04 | 1.235E-04 | 1.235E-04 | 1.235E-04 | 1.235E-04 | 1.235E-04 | 1.235E-04 |
| SB126M | 1.215E+01 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 | 8.817E-04 |
| TE127 | 3.295E+03 | 2.062E+00 | 1.635E+00 | 1.296E+00 | 1.027E+00 | 8.144E-01 | 6.456E-01 | 5.118E-01 | 4.057E-01 |
| TE127M | 6.724E+01 | 2.105E+00 | 1.669E+00 | 1.323E+00 | 1.049E+00 | 8.314E-01 | 6.591E-01 | 5.225E-01 | 4.142E-01 |
| XE127 | 3.865E-05 | 5.698E-10 | 2.843E-10 | 1.418E-10 | 7.077E-11 | 3.531E-11 | 1.762E-11 | 8.789E-12 | 4.385E-12 |

etr2.ci
ORIGEN2 V2.1 (8-1-91), Run on 10/06/04 at 12:29:23

| | 650.0HR | 1.6YR | 1.7YR | 1.8YR | 1.9YR | 2.0YR | 2.1YR | 2.2YR | 2.3YR |
|---|---|---|---|---|---|---|---|---|---|
| TE129 | 1.510E+04 | 3.919E-03 | 1.845E-03 | 8.685E-04 | 4.088E-04 | 1.924E-04 | 9.058E-05 | 4.264E-05 | 2.007E-05 |
| TE129M | 1.025E+03 | 6.021E-03 | 2.834E-03 | 1.334E-03 | 6.280E-04 | 2.956E-04 | 1.392E-04 | 6.550E-05 | 3.083E-05 |
| I129 | 4.854E-05 | 5.519E-05 | 5.519E-05 | 5.519E-05 | 5.519E-05 | 5.519E-05 | 5.519E-05 | 5.519E-05 | 5.519E-05 |
| XE131M | 4.240E+02 | 3.083E-12 | 3.672E-13 | 4.373E-14 | 5.208E-15 | 6.206E-16 | 7.364E-17 | 8.152E-18 | 1.710E-19 |
| CS134 | 5.137E+01 | 3.005E+01 | 2.905E+01 | 2.809E+01 | 2.716E+01 | 2.627E+01 | 2.540E+01 | 2.456E+01 | 2.375E+01 |
| CS135 | 1.895E-04 | 2.418E-04 | 2.418E-04 | 2.418E-04 | 2.418E-04 | 2.418E-04 | 2.418E-04 | 2.418E-04 | 2.418E-04 |
| CS136 | 1.647E+02 | 6.159E-12 | 8.919E-13 | 1.292E-13 | 1.870E-14 | 2.709E-15 | 3.918E-16 | 5.708E-17 | 8.040E-18 |
| BA136M | 2.715E+01 | 1.015E-12 | 1.470E-13 | 2.129E-14 | 3.082E-15 | 4.464E-16 | 6.465E-17 | 9.406E-18 | 1.362E-18 |
| CS137 | 2.477E+02 | 2.387E+02 | 2.382E+02 | 2.376E+02 | 2.371E+02 | 2.365E+02 | 2.360E+02 | 2.354E+02 | 2.349E+02 |
| BA137M | 2.404E+02 | 2.258E+02 | 2.253E+02 | 2.248E+02 | 2.243E+02 | 2.237E+02 | 2.232E+02 | 2.227E+02 | 2.222E+02 |
| LA138 | 4.952E-13 | 4.952E-13 | 4.952E-13 | 4.952E-13 | 4.952E-13 | 4.952E-13 | 4.952E-13 | 4.952E-13 | 4.952E-13 |
| BA140 | 1.129E+05 | 1.983E-09 | 2.739E-10 | 3.783E-11 | 5.225E-12 | 7.218E-13 | 9.970E-14 | 1.377E-14 | 1.903E-15 |
| LA140 | 1.085E+05 | 2.282E-09 | 3.152E-10 | 4.353E-11 | 6.013E-12 | 8.306E-13 | 1.147E-13 | 1.585E-14 | 2.190E-15 |
| CE141 | 6.035E+04 | 2.372E-01 | 1.089E-01 | 4.997E-02 | 2.293E-02 | 1.053E-02 | 4.832E-03 | 2.218E-03 | 1.018E-03 |
| CE142 | 6.816E-08 | 6.842E-08 | 6.842E-08 | 6.842E-08 | 6.842E-08 | 6.842E-08 | 6.842E-08 | 6.842E-08 | 6.842E-08 |
| PR143 | 9.897E+04 | 1.232E-08 | 1.906E-09 | 2.949E-10 | 4.561E-11 | 7.056E-12 | 1.091E-12 | 1.688E-13 | 2.611E-14 |
| CE144 | 8.183E+03 | 1.968E+03 | 1.800E+03 | 1.647E+03 | 1.507E+03 | 1.378E+03 | 1.261E+03 | 1.153E+03 | 1.055E+03 |
| PR144 | 1.192E+04 | 1.968E+03 | 1.801E+03 | 1.647E+03 | 1.507E+03 | 1.378E+03 | 1.261E+03 | 1.153E+03 | 1.055E+03 |
| PR144M | 9.901E+01 | 2.362E+01 | 2.161E+01 | 1.977E+01 | 1.808E+01 | 1.654E+01 | 1.513E+01 | 1.384E+01 | 1.266E+01 |
| ND144 | 2.011E-13 | 2.506E-12 | 2.568E-12 | 2.625E-12 | 2.677E-12 | 2.725E-12 | 2.768E-12 | 2.808E-12 | 2.845E-12 |
| PM146 | 9.265E-04 | 7.573E-04 | 7.478E-04 | 7.385E-04 | 7.292E-04 | 7.201E-04 | 7.111E-04 | 7.022E-04 | 6.934E-04 |
| SM146 | 9.778E-13 | 5.897E-12 | 6.172E-12 | 6.445E-12 | 6.713E-12 | 6.979E-12 | 7.241E-12 | 7.500E-12 | 7.756E-12 |
| ND147 | 4.265E+04 | 5.303E-12 | 5.375E-13 | 5.449E-14 | 5.523E-15 | 5.597E-16 | 5.623E-17 | 4.865E-18 | 0.000E+00 |
| PM147 | 4.742E+02 | 6.374E+02 | 6.208E+02 | 6.046E+02 | 5.888E+02 | 5.735E+02 | 5.585E+02 | 5.440E+02 | 5.298E+02 |
| SM147 | 8.662E-11 | 8.308E-09 | 8.716E-09 | 9.113E-09 | 9.499E-09 | 9.876E-09 | 1.024E-08 | 1.060E-08 | 1.095E-08 |
| PM148 | 1.850E+03 | 3.359E-04 | 1.820E-04 | 9.858E-05 | 5.340E-05 | 2.893E-05 | 1.567E-05 | 8.487E-06 | 4.598E-06 |
| PM148M | 1.085E+02 | 5.965E-03 | 3.231E-03 | 1.750E-03 | 9.480E-04 | 5.135E-04 | 2.782E-04 | 1.507E-04 | 8.163E-05 |
| SM148 | 4.271E-15 | 9.204E-15 | 9.204E-15 | 9.204E-15 | 9.204E-15 | 9.204E-15 | 9.204E-15 | 9.204E-15 | 9.204E-15 |
| SM149 | 5.514E-15 | 2.281E-14 | 2.281E-14 | 2.281E-14 | 2.281E-14 | 2.281E-14 | 2.281E-14 | 2.281E-14 | 2.281E-14 |
| EU150 | 2.826E-09 | 2.740E-09 | 2.735E-09 | 2.729E-09 | 2.724E-09 | 2.719E-09 | 2.714E-09 | 2.709E-09 | 2.703E-09 |
| SM151 | 1.790E+00 | 2.115E+00 | 2.114E+00 | 2.112E+00 | 2.110E+00 | 2.109E+00 | 2.107E+00 | 2.105E+00 | 2.104E+00 |
| EU152 | 3.157E-03 | 2.910E-03 | 2.895E-03 | 2.880E-03 | 2.866E-03 | 2.851E-03 | 2.837E-03 | 2.822E-03 | 2.808E-03 |
| GD152 | 1.203E-16 | 1.345E-16 | 1.350E-16 | 1.355E-16 | 1.360E-16 | 1.365E-16 | 1.370E-16 | 1.376E-16 | 1.381E-16 |
| GD153 | 4.778E-03 | 8.961E-04 | 8.071E-04 | 7.269E-04 | 6.547E-04 | 5.897E-04 | 5.311E-04 | 4.783E-04 | 4.308E-04 |
| EU154 | 2.802E+00 | 2.463E+00 | 2.444E+00 | 2.424E+00 | 2.404E+00 | 2.385E+00 | 2.366E+00 | 2.347E+00 | 2.328E+00 |
| EU155 | 5.420E+00 | 4.340E+00 | 4.280E+00 | 4.221E+00 | 4.162E+00 | 4.104E+00 | 4.047E+00 | 3.991E+00 | 3.936E+00 |
| EU156 | 5.500E+02 | 1.455E-09 | 2.746E-10 | 5.183E-11 | 9.784E-12 | 1.847E-12 | 3.486E-13 | 6.581E-14 | 1.242E-14 |
| TB160 | 1.973E-01 | 7.278E-04 | 5.128E-04 | 3.613E-04 | 2.546E-04 | 1.794E-04 | 1.264E-04 | 8.904E-05 | 6.274E-05 |

etr2.ci
ORIGEN2 V2.1 (8-1-91), Run on 10/06/04 at 12:29:23

| | 650.0HR | 1.6YR | 1.7YR | 1.8YR | 1.9YR | 2.0YR | 2.1YR | 2.2YR | 2.3YR |
|---|---|---|---|---|---|---|---|---|---|
| HO166M | 1.834E-08 | 1.832E-08 | 1.832E-08 | 1.832E-08 | 1.832E-08 | 1.832E-08 | 1.832E-08 | 1.831E-08 | 1.831E-08 |
| ER169 | 1.995E-05 | 3.845E-24 | 3.845E-24 | 3.845E-24 | 3.845E-24 | 3.845E-24 | 3.845E-24 | 3.845E-24 | 3.845E-24 |
| TM170 | 3.167E-08 | 1.357E-09 | 1.114E-09 | 9.152E-10 | 7.516E-10 | 6.173E-10 | 5.070E-10 | 4.164E-10 | 3.420E-10 |
| TM171 | 7.737E-11 | 4.342E-11 | 4.188E-11 | 4.040E-11 | 3.897E-11 | 3.758E-11 | 3.625E-11 | 3.497E-11 | 3.373E-11 |

## Appendix B
## ORIGEN2 Run ZR2

```
-1
-1
-1
  RDA     ORIGEN2, VERSION 2.1 (8-1-91) GENERIC Zr FUEL
  BAS     PWRU FUEL
  RDA     -1 = 1 KG FUEL
  CUT     -1
  LIP     0 0 0
  LIB     0  1 2 3  601  602  603   9   3   0  1   38
  TIT     INITIAL COMPOSITIONS OF UNIT AMOUNTS OF FUEL AND STRUCT MAT'LS
  INP     -1   1  -1  -1  1  1
  MOV     -1   1   0   1.0
  HED      1                                                  1 kg U-235
  TIT     IRRADIATION OF GENERIC Zr FUEL
  BUP
  IRP     100.0   .2577   1   2   4 2
  IRP     200.0   .2577   2   3   4 0
  IRP     400.0   .2577   3   4   4 0
  IRP     600.0   .2577   4   5   4 0
  IRP     800.0   .2577   5   6   4 0
  IRP    1000.0   .2577   6   7   4 0
  IRP    1200.0   .2577   7   8   4 0
  IRP    1400.0   .2577   8   9   4 0
  IRP    1600.0   .2577   9  10   4 0
  IRP    1800.0   .2577  10  11   4 0
  IRP    1826.0   .2577  11  12   4 0
  BUP
  OPTL    8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
  OPTA    8 8 8 8 5   8 5 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
  OPTF    8 8 8 8 8   8 5 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
  MOV       12    1   0  1.0
  DEC      6.6    1   2   5   4
  DEC      6.7    2   3   5   0
  DEC      6.8    3   4   5   0
  DEC      6.9    4   5   5   0
  DEC      7.0    5   6   5   0
  DEC      7.1    6   7   5   0
  DEC      7.2    7   8   5   0
  DEC      7.3    8   9   5   0
  OUT      -9    1     -1    0
  OUT       9    1     -1    0
  RDA     READ FUEL COMPOSITION INCLUDING IMPURITIES
  END
  2   922350   1000. 922360  .4366  922380  8.6636       0    0.0   FUEL 97
  0
```

Appendix B

```
echo off
echo **                                                                  **
echo **                          O R I G E N 2                           **
echo **                                                                  **
copy zr2.INP tape5.inp >nul
copy \origen2\libs\decay.lib+\origen2\libs\pwrus.lib tape9.inp >nul
copy \origen2\libs\gxuo2brm.lib tape10.inp >nul
\origen2\code\origen2
echo finished with origen2 calculation
rem  combine and save files from run
copy tape12.out+tape6.out zr2.u6 >nul
copy tape13.out+tape11.out zr2.u11 >nul
ren tape7.out zr2.pch
ren tape15.out zr2.dbg
ren tape16.out zr2.vxs
ren tape50.out zr2.ech
rem  cleanup files
del tape*.inp
del tape*.out
del zr2.pch
del zr2.dbg
del zr2.vxs
del zr2.ech
del zr2.u11
echo ************************************************************************
echo ******************* O R I G E N 2 - Version 2.1 ************************
echo ************************ Execution Completed ***************************
echo ************************************************************************
echo on
```

zr2.ci
ORIGEN2 V2.1 (8-1-91), Run on 10/07/04 at 10:10:26

| | 1826.0D | 6.6YR | 6.7YR | 6.8YR | 6.9YR | 7.0YR | 7.1YR | 7.2YR | 7.3YR |
|---|---|---|---|---|---|---|---|---|---|
| TL206 | 4.844E-21 | 4.844E-21 | 4.844E-21 | 4.844E-21 | 4.844E-21 | 4.844E-21 | 4.844E-21 | 4.844E-21 | 4.844E-21 |
| TL207 | 7.215E-09 | 3.389E-08 | 3.401E-08 | 3.440E-08 | 3.490E-08 | 3.545E-08 | 3.601E-08 | 3.657E-08 | 3.714E-08 |
| TL208 | 6.998E-06 | 5.232E-05 | 5.310E-05 | 5.354E-05 | 5.398E-05 | 5.441E-05 | 5.483E-05 | 5.524E-05 | 5.564E-05 |
| TL209 | 4.390E-11 | 1.724E-11 | 1.725E-11 | 1.728E-11 | 1.733E-11 | 1.737E-11 | 1.741E-11 | 1.746E-11 | 1.750E-11 |
| PB209 | 2.037E-09 | 7.981E-10 | 7.987E-10 | 8.002E-10 | 8.021E-10 | 8.041E-10 | 8.061E-10 | 8.081E-10 | 8.102E-10 |
| PB210 | 6.560E-12 | 8.484E-12 | 8.571E-12 | 8.661E-12 | 8.754E-12 | 8.851E-12 | 8.951E-12 | 9.053E-12 | 9.160E-12 |
| PB211 | 7.235E-09 | 3.399E-08 | 3.411E-08 | 3.449E-08 | 3.500E-08 | 3.555E-08 | 3.611E-08 | 3.667E-08 | 3.724E-08 |
| PB212 | 1.948E-05 | 1.456E-04 | 1.478E-04 | 1.490E-04 | 1.502E-04 | 1.514E-04 | 1.526E-04 | 1.537E-04 | 1.549E-04 |
| PB214 | 2.127E-12 | 3.614E-11 | 3.704E-11 | 3.812E-11 | 3.922E-11 | 4.034E-11 | 4.148E-11 | 4.264E-11 | 4.383E-11 |
| BI208 | 5.624E-21 | 5.624E-21 | 5.624E-21 | 5.624E-21 | 5.624E-21 | 5.624E-21 | 5.624E-21 | 5.624E-21 | 5.624E-21 |
| BI210M | 4.863E-21 | 4.863E-21 | 4.863E-21 | 4.863E-21 | 4.863E-21 | 4.863E-21 | 4.863E-21 | 4.863E-21 | 4.863E-21 |
| BI210 | 6.481E-12 | 8.487E-12 | 8.554E-12 | 8.643E-12 | 8.736E-12 | 8.832E-12 | 8.931E-12 | 9.033E-12 | 9.138E-12 |
| BI211 | 7.235E-09 | 3.399E-08 | 3.411E-08 | 3.449E-08 | 3.500E-08 | 3.555E-08 | 3.611E-08 | 3.667E-08 | 3.724E-08 |
| BI212 | 1.948E-05 | 1.456E-04 | 1.478E-04 | 1.490E-04 | 1.502E-04 | 1.514E-04 | 1.526E-04 | 1.537E-04 | 1.549E-04 |
| BI213 | 2.032E-09 | 7.981E-10 | 7.987E-10 | 8.002E-10 | 8.021E-10 | 8.041E-10 | 8.061E-10 | 8.081E-10 | 8.102E-10 |
| BI214 | 2.127E-12 | 3.614E-11 | 3.704E-11 | 3.812E-11 | 3.922E-11 | 4.034E-11 | 4.148E-11 | 4.264E-11 | 4.383E-11 |
| PO210 | 4.211E-12 | 8.487E-12 | 8.492E-12 | 8.510E-12 | 8.540E-12 | 8.581E-12 | 8.632E-12 | 8.690E-12 | 8.757E-12 |
| PO211 | 2.026E-11 | 9.517E-11 | 9.550E-11 | 9.658E-11 | 9.800E-11 | 9.953E-11 | 1.011E-10 | 1.027E-10 | 1.043E-10 |
| PO212 | 1.248E-05 | 9.330E-05 | 9.468E-05 | 9.548E-05 | 9.626E-05 | 9.702E-05 | 9.777E-05 | 9.850E-05 | 9.922E-05 |
| PO213 | 1.988E-09 | 7.808E-10 | 7.814E-10 | 7.829E-10 | 7.848E-10 | 7.867E-10 | 7.887E-10 | 7.907E-10 | 7.927E-10 |
| PO214 | 2.076E-10 | 3.613E-11 | 3.703E-11 | 3.811E-11 | 3.921E-11 | 4.033E-11 | 4.147E-11 | 4.264E-11 | 4.382E-11 |
| PO215 | 7.235E-09 | 3.399E-08 | 3.411E-08 | 3.449E-08 | 3.500E-08 | 3.555E-08 | 3.611E-08 | 3.667E-08 | 3.724E-08 |
| PO216 | 1.948E-05 | 1.456E-04 | 1.478E-04 | 1.490E-04 | 1.502E-04 | 1.514E-04 | 1.526E-04 | 1.537E-04 | 1.548E-04 |
| PO218 | 2.127E-12 | 3.615E-11 | 3.705E-11 | 3.812E-11 | 3.922E-11 | 4.035E-11 | 4.149E-11 | 4.265E-11 | 4.384E-11 |
| AT217 | 2.032E-09 | 7.981E-10 | 7.987E-10 | 8.002E-10 | 8.021E-10 | 8.041E-10 | 8.061E-10 | 8.081E-10 | 8.102E-10 |
| RN219 | 7.235E-09 | 3.399E-08 | 3.411E-08 | 3.449E-08 | 3.500E-08 | 3.555E-08 | 3.611E-08 | 3.667E-08 | 3.724E-08 |
| RN220 | 1.948E-05 | 1.456E-04 | 1.478E-04 | 1.490E-04 | 1.502E-04 | 1.514E-04 | 1.526E-04 | 1.537E-04 | 1.548E-04 |
| RN222 | 2.127E-12 | 3.615E-11 | 3.705E-11 | 3.812E-11 | 3.922E-11 | 4.035E-11 | 4.149E-11 | 4.265E-11 | 4.384E-11 |
| FR221 | 2.032E-09 | 7.981E-10 | 7.987E-10 | 8.002E-10 | 8.021E-10 | 8.041E-10 | 8.061E-10 | 8.081E-10 | 8.102E-10 |
| FR223 | 1.004E-10 | 4.689E-10 | 4.765E-10 | 4.841E-10 | 4.919E-10 | 4.996E-10 | 5.075E-10 | 5.154E-10 | 5.234E-10 |
| RA223 | 7.235E-09 | 3.399E-08 | 3.411E-08 | 3.449E-08 | 3.500E-08 | 3.555E-08 | 3.611E-08 | 3.667E-08 | 3.724E-08 |
| RA224 | 1.948E-05 | 1.456E-04 | 1.478E-04 | 1.490E-04 | 1.502E-04 | 1.514E-04 | 1.526E-04 | 1.537E-04 | 1.548E-04 |
| RA225 | 2.087E-09 | 7.981E-10 | 7.991E-10 | 8.009E-10 | 8.028E-10 | 8.048E-10 | 8.069E-10 | 8.089E-10 | 8.110E-10 |
| RA226 | 2.146E-12 | 3.615E-11 | 3.721E-11 | 3.829E-11 | 3.939E-11 | 4.052E-11 | 4.166E-11 | 4.283E-11 | 4.402E-11 |
| RA228 | 1.285E-13 | 1.076E-12 | 1.096E-12 | 1.116E-12 | 1.136E-12 | 1.157E-12 | 1.177E-12 | 1.198E-12 | 1.219E-12 |

zr2.ci
ORIGEN2 V2.1 (8-1-91), Run on 10/07/04 at 10:10:26

| | 1826.0D | 6.6YR | 6.7YR | 6.8YR | 6.9YR | 7.0YR | 7.1YR | 7.2YR | 7.3YR |
|---|---|---|---|---|---|---|---|---|---|
| AC225 | 2.032E-09 | 7.981E-10 | 7.986E-10 | 8.002E-10 | 8.021E-10 | 8.041E-10 | 8.061E-10 | 8.081E-10 | 8.102E-10 |
| AC227 | 7.278E-09 | 3.398E-08 | 3.453E-08 | 3.508E-08 | 3.564E-08 | 3.621E-08 | 3.677E-08 | 3.735E-08 | 3.792E-08 |
| AC228 | 5.130E-08 | 1.076E-12 | 1.096E-12 | 1.116E-12 | 1.136E-12 | 1.157E-12 | 1.177E-12 | 1.198E-12 | 1.219E-12 |
| TH227 | 7.136E-09 | 3.352E-08 | 3.376E-08 | 3.422E-08 | 3.475E-08 | 3.530E-08 | 3.585E-08 | 3.642E-08 | 3.698E-08 |
| TH228 | 1.967E-05 | 1.456E-04 | 1.469E-04 | 1.481E-04 | 1.493E-04 | 1.505E-04 | 1.517E-04 | 1.528E-04 | 1.539E-04 |
| TH229 | 7.115E-10 | 7.981E-10 | 8.000E-10 | 8.020E-10 | 8.040E-10 | 8.060E-10 | 8.081E-10 | 8.101E-10 | 8.122E-10 |
| TH230 | 3.041E-09 | 2.428E-08 | 2.477E-08 | 2.525E-08 | 2.575E-08 | 2.624E-08 | 2.674E-08 | 2.725E-08 | 2.776E-08 |
| TH231 | 9.064E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 |
| TH232 | 8.375E-13 | 3.004E-12 | 3.037E-12 | 3.069E-12 | 3.102E-12 | 3.135E-12 | 3.168E-12 | 3.201E-12 | 3.233E-12 |
| TH234 | 2.889E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 |
| PA231 | 8.558E-08 | 2.064E-07 | 2.083E-07 | 2.102E-07 | 2.121E-07 | 2.140E-07 | 2.160E-07 | 2.179E-07 | 2.198E-07 |
| PA233 | 4.612E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 |
| PA234M | 3.337E-05 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 |
| PA234 | 3.061E-05 | 3.744E-09 | 3.744E-09 | 3.744E-09 | 3.744E-09 | 3.744E-09 | 3.744E-09 | 3.744E-09 | 3.744E-09 |
| U232 | 6.530E-05 | 1.807E-04 | 1.812E-04 | 1.818E-04 | 1.823E-04 | 1.829E-04 | 1.834E-04 | 1.839E-04 | 1.843E-04 |
| U233 | 7.026E-08 | 2.069E-07 | 2.090E-07 | 2.110E-07 | 2.131E-07 | 2.152E-07 | 2.172E-07 | 2.193E-07 | 2.214E-07 |
| U234 | 1.786E-04 | 5.335E-04 | 5.387E-04 | 5.440E-04 | 5.492E-04 | 5.544E-04 | 5.596E-04 | 5.649E-04 | 5.701E-04 |
| U235 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 | 8.650E-04 |
| U236 | 6.653E-03 | 6.653E-03 | 6.653E-03 | 6.653E-03 | 6.653E-03 | 6.653E-03 | 6.653E-03 | 6.653E-03 | 6.653E-03 |
| U237 | 9.421E+03 | 1.606E-05 | 1.598E-05 | 1.590E-05 | 1.582E-05 | 1.575E-05 | 1.567E-05 | 1.560E-05 | 1.552E-05 |
| U238 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 | 2.880E-06 |
| U240 | 5.196E-05 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 |
| NP235 | 4.563E-05 | 6.714E-07 | 6.298E-07 | 5.908E-07 | 5.542E-07 | 5.199E-07 | 4.877E-07 | 4.575E-07 | 4.292E-07 |
| NP236 | 4.940E-08 | 4.940E-08 | 4.940E-08 | 4.940E-08 | 4.940E-08 | 4.940E-08 | 4.940E-08 | 4.940E-08 | 4.940E-08 |
| NP237 | 4.654E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 | 4.735E-03 |
| NP238 | 2.425E+03 | 4.751E-07 | 4.749E-07 | 4.746E-07 | 4.744E-07 | 4.742E-07 | 4.740E-07 | 4.738E-07 | 4.736E-07 |
| NP239 | 8.563E+01 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 |
| NP240M | 1.081E-02 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 | 2.244E-13 |
| PU236 | 3.906E-03 | 7.886E-04 | 7.697E-04 | 7.512E-04 | 7.331E-04 | 7.155E-04 | 6.983E-04 | 6.816E-04 | 6.652E-04 |
| PU237 | 9.141E-03 | 1.114E-18 | 4.956E-19 | 4.956E-19 | 4.956E-19 | 4.956E-19 | 4.956E-19 | 4.956E-19 | 4.956E-19 |
| PU238 | 1.931E+01 | 1.848E+01 | 1.847E+01 | 1.845E+01 | 1.844E+01 | 1.842E+01 | 1.841E+01 | 1.839E+01 | 1.838E+01 |
| PU239 | 1.003E-02 | 1.005E-02 | 1.005E-02 | 1.005E-02 | 1.005E-02 | 1.005E-02 | 1.005E-02 | 1.005E-02 | 1.005E-02 |
| PU240 | 7.658E-03 | 7.653E-03 | 7.653E-03 | 7.653E-03 | 7.653E-03 | 7.653E-03 | 7.653E-03 | 7.653E-03 | 7.653E-03 |
| PU241 | 8.992E-01 | 6.545E-01 | 6.513E-01 | 6.482E-01 | 6.451E-01 | 6.420E-01 | 6.389E-01 | 6.358E-01 | 6.328E-01 |
| PU242 | 4.641E-06 | 4.642E-06 | 4.642E-06 | 4.642E-06 | 4.642E-06 | 4.642E-06 | 4.642E-06 | 4.642E-06 | 4.642E-06 |
| PU243 | 3.981E-01 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 |
| PU244 | 2.246E-13 | 2.247E-13 | 2.247E-13 | 2.247E-13 | 2.247E-13 | 2.247E-13 | 2.247E-13 | 2.247E-13 | 2.247E-13 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PU246 | 1.968E-11 | 7.470E-23 | 7.470E-23 | 7.470E-23 | 7.470E-23 | 7.470E-23 | 7.470E-23 | 7.470E-23 | 7.470E-23 |

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**ORIGEN2 V2.1 (8-1-91), Run on 10/07/04 at 10:10:26**

| | **1826.0D** | **6.6YR** | **6.7YR** | **6.8YR** | **6.9YR** | **7.0YR** | **7.1YR** | **7.2YR** | **7.3YR** |
|---|---|---|---|---|---|---|---|---|---|
| AM241 | 1.053E-03 | 9.151E-03 | 9.254E-03 | 9.357E-03 | 9.459E-03 | 9.560E-03 | 9.662E-03 | 9.762E-03 | 9.862E-03 |
| AM242M | 9.791E-05 | 9.501E-05 | 9.497E-05 | 9.492E-05 | 9.488E-05 | 9.484E-05 | 9.479E-05 | 9.475E-05 | 9.471E-05 |
| AM242 | 2.537E-01 | 9.454E-05 | 9.449E-05 | 9.445E-05 | 9.441E-05 | 9.436E-05 | 9.432E-05 | 9.428E-05 | 9.423E-05 |
| AM243 | 2.296E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 | 2.297E-05 |
| AM245 | 1.506E-07 | 2.595E-18 | 2.398E-18 | 2.216E-18 | 2.047E-18 | 1.891E-18 | 1.747E-18 | 1.615E-18 | 1.492E-18 |
| AM246 | 1.968E-11 | 7.470E-23 | 7.471E-23 | 7.471E-23 | 7.471E-23 | 7.471E-23 | 7.471E-23 | 7.471E-23 | 7.471E-23 |
| CM241 | 1.622E-08 | 1.128E-28 | 1.128E-28 | 1.128E-28 | 1.128E-28 | 1.128E-28 | 1.128E-28 | 1.128E-28 | 1.128E-28 |
| CM242 | 1.174E-01 | 8.241E-05 | 8.178E-05 | 8.123E-05 | 8.076E-05 | 8.035E-05 | 7.999E-05 | 7.968E-05 | 7.941E-05 |
| CM243 | 2.912E-05 | 2.480E-05 | 2.474E-05 | 2.468E-05 | 2.462E-05 | 2.456E-05 | 2.450E-05 | 2.444E-05 | 2.438E-05 |
| CM244 | 1.315E-03 | 1.021E-03 | 1.017E-03 | 1.014E-03 | 1.010E-03 | 1.006E-03 | 1.002E-03 | 9.982E-04 | 9.944E-04 |
| CM245 | 6.304E-08 | 6.301E-08 | 6.301E-08 | 6.301E-08 | 6.300E-08 | 6.300E-08 | 6.300E-08 | 6.300E-08 | 6.300E-08 |
| CM246 | 6.789E-09 | 6.782E-09 | 6.782E-09 | 6.782E-09 | 6.782E-09 | 6.782E-09 | 6.782E-09 | 6.782E-09 | 6.782E-09 |
| CM247 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 | 1.067E-14 |
| CM248 | 1.464E-14 | 1.464E-14 | 1.464E-14 | 1.464E-14 | 1.464E-14 | 1.464E-14 | 1.464E-14 | 1.464E-14 | 1.464E-14 |
| CM250 | 2.974E-22 | 2.988E-22 | 2.988E-22 | 2.988E-22 | 2.988E-22 | 2.988E-22 | 2.988E-22 | 2.988E-22 | 2.988E-22 |
| BK249 | 3.309E-11 | 1.789E-13 | 1.653E-13 | 1.528E-13 | 1.411E-13 | 1.304E-13 | 1.205E-13 | 1.113E-13 | 1.029E-13 |
| BK250 | 4.778E-11 | 1.190E-19 | 1.190E-19 | 1.190E-19 | 1.190E-19 | 1.190E-19 | 1.190E-19 | 1.190E-19 | 1.190E-19 |
| CF249 | 1.589E-14 | 9.718E-14 | 9.719E-14 | 9.720E-14 | 9.721E-14 | 9.722E-14 | 9.723E-14 | 9.723E-14 | 9.723E-14 |
| CF250 | 3.729E-13 | 2.638E-13 | 2.624E-13 | 2.610E-13 | 2.596E-13 | 2.582E-13 | 2.569E-13 | 2.555E-13 | 2.542E-13 |
| CF251 | 1.679E-15 | 1.670E-15 | 1.670E-15 | 1.670E-15 | 1.670E-15 | 1.670E-15 | 1.670E-15 | 1.670E-15 | 1.670E-15 |
| CF252 | 1.729E-13 | 3.052E-14 | 2.973E-14 | 2.896E-14 | 2.821E-14 | 2.748E-14 | 2.676E-14 | 2.607E-14 | 2.539E-14 |
| CF254 | 4.786E-17 | 4.845E-29 | 4.845E-29 | 4.845E-29 | 4.845E-29 | 4.845E-29 | 4.845E-29 | 4.845E-29 | 4.845E-29 |
| ES254 | 4.326E-17 | 1.189E-19 | 1.189E-19 | 1.189E-19 | 1.189E-19 | 1.189E-19 | 1.189E-19 | 1.189E-19 | 1.189E-19 |
| ES255 | 1.904E-18 | 4.694E-37 | 4.694E-37 | 4.694E-37 | 4.694E-37 | 4.694E-37 | 4.694E-37 | 4.694E-37 | 4.694E-37 |
| H 3 | 5.806E+00 | 4.008E+00 | 3.986E+00 | 3.964E+00 | 3.941E+00 | 3.919E+00 | 3.897E+00 | 3.876E+00 | 3.854E+00 |
| BE 10 | 4.196E-08 | 4.196E-08 | 4.196E-08 | 4.196E-08 | 4.196E-08 | 4.196E-08 | 4.196E-08 | 4.196E-08 | 4.196E-08 |
| C 14 | 1.692E-06 | 1.691E-06 | 1.691E-06 | 1.691E-06 | 1.691E-06 | 1.691E-06 | 1.691E-06 | 1.691E-06 | 1.691E-06 |
| SE 79 | 6.079E-03 | 6.079E-03 | 6.079E-03 | 6.079E-03 | 6.079E-03 | 6.079E-03 | 6.079E-03 | 6.079E-03 | 6.079E-03 |
| KR 81 | 8.776E-10 | 8.776E-10 | 8.776E-10 | 8.776E-10 | 8.776E-10 | 8.776E-10 | 8.776E-10 | 8.776E-10 | 8.776E-10 |
| KR 85 | 1.616E+02 | 1.055E+02 | 1.048E+02 | 1.041E+02 | 1.034E+02 | 1.028E+02 | 1.021E+02 | 1.015E+02 | 1.008E+02 |
| RB 87 | 4.092E-07 | 4.092E-07 | 4.092E-07 | 4.092E-07 | 4.092E-07 | 4.092E-07 | 4.092E-07 | 4.092E-07 | 4.092E-07 |
| SR 89 | 1.008E+04 | 4.295E-11 | 2.602E-11 | 1.576E-11 | 9.546E-12 | 5.782E-12 | 3.502E-12 | 2.121E-12 | 1.285E-12 |
| SR 90 | 1.382E+03 | 1.181E+03 | 1.178E+03 | 1.176E+03 | 1.173E+03 | 1.170E+03 | 1.167E+03 | 1.165E+03 | 1.162E+03 |
| Y 90 | 1.412E+03 | 1.182E+03 | 1.179E+03 | 1.176E+03 | 1.173E+03 | 1.170E+03 | 1.168E+03 | 1.165E+03 | 1.162E+03 |
| Y 91 | 1.232E+04 | 4.903E-09 | 3.181E-09 | 2.063E-09 | 1.339E-09 | 8.684E-10 | 5.634E-10 | 3.655E-10 | 2.371E-10 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ZR 93 | 3.125E-02 | 3.126E-02 | 3.126E-02 | 3.126E-02 | 3.126E-02 | 3.126E-02 | 3.126E-02 | 3.126E-02 | 3.126E-02 |
| NB 93M | 3.505E-03 | 1.099E-02 | 1.108E-02 | 1.118E-02 | 1.127E-02 | 1.136E-02 | 1.146E-02 | 1.155E-02 | 1.164E-02 |

**zr2.ci**

**ORIGEN2 V2.1 (8-1-91), Run on 10/07/04 at 10:10:26**

| | **1826.0D** | **6.6YR** | **6.7YR** | **6.8YR** | **6.9YR** | **7.0YR** | **7.1YR** | **7.2YR** | **7.3YR** |
|---|---|---|---|---|---|---|---|---|---|
| NB 94 | 3.100E-07 | 3.100E-07 | 3.100E-07 | 3.100E-07 | 3.100E-07 | 3.100E-07 | 3.100E-07 | 3.100E-07 | 3.100E-07 |
| ZR 95 | 1.354E+04 | 6.159E-08 | 4.146E-08 | 2.791E-08 | 1.879E-08 | 1.265E-08 | 8.517E-09 | 5.734E-09 | 3.860E-09 |
| NB 95 | 1.361E+04 | 1.367E-07 | 9.205E-08 | 6.197E-08 | 4.171E-08 | 2.808E-08 | 1.890E-08 | 1.273E-08 | 8.568E-09 |
| NB 95M | 9.495E+01 | 4.569E-10 | 3.080E-10 | 2.074E-10 | 1.396E-10 | 9.398E-11 | 6.327E-11 | 4.259E-11 | 2.867E-11 |
| TC 98 | 3.974E-08 | 3.974E-08 | 3.974E-08 | 3.974E-08 | 3.974E-08 | 3.974E-08 | 3.974E-08 | 3.974E-08 | 3.974E-08 |
| TC 99 | 1.950E-01 | 1.955E-01 | 1.955E-01 | 1.955E-01 | 1.955E-01 | 1.955E-01 | 1.955E-01 | 1.955E-01 | 1.955E-01 |
| RH102 | 6.436E-03 | 1.329E-03 | 1.298E-03 | 1.267E-03 | 1.237E-03 | 1.208E-03 | 1.179E-03 | 1.151E-03 | 1.124E-03 |
| RU103 | 6.672E+03 | 2.243E-15 | 1.177E-15 | 6.180E-16 | 3.243E-16 | 1.705E-16 | 8.965E-17 | 4.714E-17 | 2.478E-17 |
| RH103M | 6.012E+03 | 2.022E-15 | 1.062E-15 | 5.572E-16 | 2.924E-16 | 1.537E-16 | 8.082E-17 | 4.249E-17 | 2.234E-17 |
| RU106 | 8.686E+02 | 9.285E+00 | 8.668E+00 | 8.092E+00 | 7.554E+00 | 7.052E+00 | 6.584E+00 | 6.146E+00 | 5.738E+00 |
| RH106 | 9.317E+02 | 9.285E+00 | 8.668E+00 | 8.092E+00 | 7.554E+00 | 7.052E+00 | 6.584E+00 | 6.146E+00 | 5.738E+00 |
| PD107 | 2.178E-04 | 2.178E-04 | 2.178E-04 | 2.178E-04 | 2.178E-04 | 2.178E-04 | 2.178E-04 | 2.178E-04 | 2.178E-04 |
| AG108 | 7.020E-04 | 6.890E-10 | 6.886E-10 | 6.882E-10 | 6.878E-10 | 6.874E-10 | 6.871E-10 | 6.867E-10 | 6.863E-10 |
| AG108M | 8.025E-09 | 7.741E-09 | 7.737E-09 | 7.733E-09 | 7.728E-09 | 7.724E-09 | 7.720E-09 | 7.716E-09 | 7.712E-09 |
| AG109M | 1.335E+02 | 1.594E-08 | 1.510E-08 | 1.429E-08 | 1.353E-08 | 1.282E-08 | 1.214E-08 | 1.149E-08 | 1.088E-08 |
| CD109 | 5.841E-07 | 1.594E-08 | 1.510E-08 | 1.429E-08 | 1.353E-08 | 1.282E-08 | 1.214E-08 | 1.149E-08 | 1.088E-08 |
| AG110 | 7.834E+01 | 4.258E-05 | 3.848E-05 | 3.477E-05 | 3.142E-05 | 2.839E-05 | 2.566E-05 | 2.319E-05 | 2.095E-05 |
| AG110M | 2.567E+00 | 3.202E-03 | 2.893E-03 | 2.614E-03 | 2.362E-03 | 2.135E-03 | 1.929E-03 | 1.743E-03 | 1.575E-03 |
| CD113M | 1.906E-01 | 1.393E-01 | 1.387E-01 | 1.380E-01 | 1.374E-01 | 1.367E-01 | 1.361E-01 | 1.354E-01 | 1.348E-01 |
| IN114 | 2.417E-02 | 1.937E-17 | 1.162E-17 | 6.937E-18 | 4.279E-18 | 2.650E-18 | 1.642E-18 | 9.844E-19 | 4.811E-19 |
| IN114M | 9.169E-03 | 2.024E-17 | 1.209E-17 | 7.218E-18 | 4.471E-18 | 2.769E-18 | 1.715E-18 | 8.382E-19 | 4.096E-19 |
| CD115M | 3.097E+00 | 1.653E-16 | 9.379E-17 | 5.320E-17 | 2.995E-17 | 1.686E-17 | 9.491E-18 | 5.632E-18 | 3.342E-18 |
| IN115 | 6.915E-14 | 7.032E-14 | 7.032E-14 | 7.032E-14 | 7.032E-14 | 7.032E-14 | 7.032E-14 | 7.032E-14 | 7.032E-14 |
| IN115M | 3.247E+01 | 1.162E-20 | 6.591E-21 | 3.739E-21 | 2.119E-21 | 1.193E-21 | 6.716E-22 | 3.958E-22 | 2.349E-22 |
| SN119M | 6.374E-01 | 6.976E-04 | 6.291E-04 | 5.674E-04 | 5.117E-04 | 4.614E-04 | 4.161E-04 | 3.753E-04 | 3.384E-04 |
| SN121M | 1.275E-03 | 1.163E-03 | 1.161E-03 | 1.160E-03 | 1.158E-03 | 1.157E-03 | 1.155E-03 | 1.153E-03 | 1.152E-03 |
| SN123 | 1.212E+01 | 2.920E-05 | 2.400E-05 | 1.973E-05 | 1.622E-05 | 1.333E-05 | 1.096E-05 | 9.007E-06 | 7.404E-06 |
| TE123 | 6.391E-15 | 7.289E-15 | 7.289E-15 | 7.289E-15 | 7.289E-15 | 7.289E-15 | 7.289E-15 | 7.289E-15 | 7.289E-15 |
| TE123M | 2.742E-02 | 2.368E-08 | 1.916E-08 | 1.551E-08 | 1.255E-08 | 1.016E-08 | 8.222E-09 | 6.654E-09 | 5.385E-09 |
| SB124 | 3.634E+00 | 3.201E-12 | 2.102E-12 | 1.380E-12 | 9.063E-13 | 5.952E-13 | 3.908E-13 | 2.566E-13 | 1.685E-13 |
| SB125 | 6.065E+01 | 1.169E+01 | 1.140E+01 | 1.112E+01 | 1.084E+01 | 1.058E+01 | 1.032E+01 | 1.006E+01 | 9.812E+00 |
| TE125M | 1.365E+01 | 2.852E+00 | 2.782E+00 | 2.713E+00 | 2.646E+00 | 2.581E+00 | 2.517E+00 | 2.455E+00 | 2.394E+00 |
| SN126 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 |
| SB126 | 3.027E+00 | 7.550E-04 | 7.551E-04 | 7.551E-04 | 7.551E-04 | 7.551E-04 | 7.551E-04 | 7.551E-04 | 7.551E-04 |
| SB126M | 1.161E+00 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 | 5.393E-03 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TE127 | 3.401E+02 | 1.043E-05 | 8.267E-06 | 6.553E-06 | 5.195E-06 | 4.118E-06 | 3.265E-06 | 2.588E-06 | 2.052E-06 |
| TE127M | 4.660E+01 | 1.065E-05 | 8.440E-06 | 6.691E-06 | 5.304E-06 | 4.205E-06 | 3.333E-06 | 2.642E-06 | 2.095E-06 |
| XE127 | 1.051E-04 | 1.236E-24 | 1.236E-24 | 1.236E-24 | 1.236E-24 | 1.236E-24 | 1.236E-24 | 1.236E-24 | 1.236E-24 |

**zr2.ci**

**ORIGEN2 V2.1 (8-1-91), Run on 10/07/04 at 10:10:26**

| | **1826.0D** | **6.6YR** | **6.7YR** | **6.8YR** | **6.9YR** | **7.0YR** | **7.1YR** | **7.2YR** | **7.3YR** |
|---|---|---|---|---|---|---|---|---|---|
| TE129 | 1.451E+03 | 3.534E-20 | 3.531E-20 | 3.531E-20 | 3.531E-20 | 3.531E-20 | 3.531E-20 | 3.531E-20 | 3.531E-20 |
| TE129M | 2.140E+02 | 5.429E-20 | 5.429E-20 | 5.429E-20 | 5.429E-20 | 5.429E-20 | 5.429E-20 | 5.429E-20 | 5.429E-20 |
| I129 | 3.241E-04 | 3.254E-04 | 3.254E-04 | 3.254E-04 | 3.254E-04 | 3.254E-04 | 3.254E-04 | 3.254E-04 | 3.254E-04 |
| CS134 | 1.455E+03 | 1.582E+02 | 1.530E+02 | 1.479E+02 | 1.430E+02 | 1.383E+02 | 1.337E+02 | 1.293E+02 | 1.250E+02 |
| CS135 | 1.047E-02 | 1.048E-02 | 1.048E-02 | 1.048E-02 | 1.048E-02 | 1.048E-02 | 1.048E-02 | 1.048E-02 | 1.048E-02 |
| CS137 | 1.437E+03 | 1.234E+03 | 1.231E+03 | 1.228E+03 | 1.225E+03 | 1.222E+03 | 1.220E+03 | 1.217E+03 | 1.214E+03 |
| BA137M | 1.360E+03 | 1.167E+03 | 1.164E+03 | 1.162E+03 | 1.159E+03 | 1.156E+03 | 1.154E+03 | 1.151E+03 | 1.148E+03 |
| LA138 | 2.631E-12 | 2.631E-12 | 2.631E-12 | 2.631E-12 | 2.631E-12 | 2.631E-12 | 2.631E-12 | 2.631E-12 | 2.631E-12 |
| CE142 | 4.183E-07 | 4.183E-07 | 4.183E-07 | 4.183E-07 | 4.183E-07 | 4.183E-07 | 4.183E-07 | 4.183E-07 | 4.183E-07 |
| CE144 | 1.145E+04 | 3.204E+01 | 2.931E+01 | 2.681E+01 | 2.453E+01 | 2.244E+01 | 2.053E+01 | 1.878E+01 | 1.718E+01 |
| PR144 | 1.149E+04 | 3.206E+01 | 2.931E+01 | 2.681E+01 | 2.453E+01 | 2.244E+01 | 2.053E+01 | 1.878E+01 | 1.718E+01 |
| PR144M | 1.375E+02 | 3.848E-01 | 3.517E-01 | 3.218E-01 | 2.943E-01 | 2.693E-01 | 2.463E-01 | 2.253E-01 | 2.061E-01 |
| ND144 | 1.939E-11 | 2.362E-11 | 2.362E-11 | 2.362E-11 | 2.362E-11 | 2.362E-11 | 2.363E-11 | 2.363E-11 | 2.363E-11 |
| PM146 | 2.209E-02 | 9.615E-03 | 9.495E-03 | 9.376E-03 | 9.259E-03 | 9.143E-03 | 9.028E-03 | 8.915E-03 | 8.803E-03 |
| SM146 | 2.861E-09 | 3.224E-09 | 3.227E-09 | 3.231E-09 | 3.234E-09 | 3.238E-09 | 3.241E-09 | 3.244E-09 | 3.248E-09 |
| PM147 | 1.949E+03 | 3.507E+02 | 3.416E+02 | 3.327E+02 | 3.240E+02 | 3.156E+02 | 3.073E+02 | 2.993E+02 | 2.915E+02 |
| SM147 | 4.213E-08 | 8.271E-08 | 8.293E-08 | 8.315E-08 | 8.336E-08 | 8.357E-08 | 8.377E-08 | 8.397E-08 | 8.416E-08 |
| PM148 | 2.092E+03 | 5.056E-17 | 2.906E-17 | 1.561E-17 | 7.231E-18 | 5.668E-18 | 1.021E-18 | 2.658E-18 | 0.000E+00 |
| PM148M | 3.354E+02 | 8.976E-16 | 4.861E-16 | 2.633E-16 | 1.428E-16 | 7.745E-17 | 4.200E-17 | 2.253E-17 | 1.209E-17 |
| SM148 | 6.979E-13 | 7.065E-13 | 7.065E-13 | 7.065E-13 | 7.065E-13 | 7.065E-13 | 7.065E-13 | 7.065E-13 | 7.065E-13 |
| SM149 | 6.754E-15 | 8.921E-15 | 8.921E-15 | 8.921E-15 | 8.921E-15 | 8.921E-15 | 8.921E-15 | 8.921E-15 | 8.921E-15 |
| EU150 | 3.005E-07 | 2.646E-07 | 2.641E-07 | 2.636E-07 | 2.631E-07 | 2.626E-07 | 2.621E-07 | 2.616E-07 | 2.611E-07 |
| SM151 | 4.307E+00 | 4.125E+00 | 4.122E+00 | 4.119E+00 | 4.116E+00 | 4.112E+00 | 4.109E+00 | 4.106E+00 | 4.103E+00 |
| EU152 | 2.107E-01 | 1.505E-01 | 1.497E-01 | 1.490E-01 | 1.482E-01 | 1.475E-01 | 1.467E-01 | 1.460E-01 | 1.452E-01 |
| GD152 | 2.421E-14 | 2.633E-14 | 2.635E-14 | 2.638E-14 | 2.641E-14 | 2.643E-14 | 2.646E-14 | 2.649E-14 | 2.651E-14 |
| GD153 | 1.527E-01 | 1.539E-04 | 1.386E-04 | 1.248E-04 | 1.124E-04 | 1.013E-04 | 9.119E-05 | 8.214E-05 | 7.398E-05 |
| EU154 | 6.988E+01 | 4.105E+01 | 4.072E+01 | 4.040E+01 | 4.007E+01 | 3.975E+01 | 3.943E+01 | 3.912E+01 | 3.880E+01 |
| EU155 | 3.712E+01 | 1.476E+01 | 1.455E+01 | 1.435E+01 | 1.415E+01 | 1.396E+01 | 1.376E+01 | 1.357E+01 | 1.338E+01 |
| TB160 | 8.874E-01 | 8.157E-11 | 5.747E-11 | 4.049E-11 | 2.853E-11 | 2.010E-11 | 1.416E-11 | 9.979E-12 | 7.031E-12 |
| HO166M | 8.309E-07 | 8.277E-07 | 8.277E-07 | 8.276E-07 | 8.276E-07 | 8.275E-07 | 8.275E-07 | 8.274E-07 | 8.274E-07 |
| TM170 | 6.559E-06 | 1.491E-11 | 1.224E-11 | 1.006E-11 | 8.258E-12 | 6.782E-12 | 5.570E-12 | 4.575E-12 | 3.757E-12 |
| TM171 | 6.258E-08 | 5.776E-09 | 5.571E-09 | 5.374E-09 | 5.183E-09 | 5.000E-09 | 4.822E-09 | 4.651E-09 | 4.486E-09 |

# Appendix C
## Radiation Readings in Monitoring Test Holes

TABLE I

TEST HOLE RADIATION READINGS
(mR/hr)

| | MONITORING TEST HOLES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | No. 9 | No. 10 | No. 11 |
| 0'-0" | | | | | 30 | | | | | | |
| (-) 1'-0" | 35 | | | | 35 | 25 | 20 | 40 | 10 | 40 | 40 |
| (-) 2'-0" | 35 | 50 | 25 | 60 | 50 | 30 | 15 | 50 | 40 | 40 | 40 |
| (-) 3'-0" | 35 | 50 | 25 | 70 | 60 | 35 | 6 | 70 | 40 | 40 | 50 |
| (-) 4'-0" | 35 | 50 | 25 | 100 | 60 | 70 | 2 | 80 | 40 | 50 | 60 |
| (-) 5'-0" | 30 | 50 | 25 | 150 | 70 | 200 | 3 | 100 | 40 | 60 | 50 |
| (-) 6'-0" | 7 | 200 | 18 | 200 | 60 | 250 | 10 | 350 | 12 | 90 | 150 |
| (-) 7'-0" | 7 | 1,500 | 3 | 1,500<br>5,500 | 100 | 150 | 10 | 2,000<br>7,000 | 8 | 350 | 5,000 |
| (-) 8'-0" | 7 | 300 | 2 | 35,000<br>20,000 | 2,000 | 40 | 10 | 12,000<br>90,000 | 8 | 11,000 | 11,000 |
| (-) 9'-0" | 50 | 60 | 1 | 3,000<br>800 | 50 | 20 | 50 | 65,000<br>10,000 | 6 | 50,000<br>4,000 | 250 |
| (-)10'-0" | 40 | 5 | 0.6 | 100 | 20 | 4 | 250 | 1,000 | | 50 | 10 |
| (-)11'-0" | 20 | 5 | 0.5 | 10 | 50 | 1 | 50 | 12 | <5 | 7 | 2 |
| (-)12'-0" | 10 | 1.5 | <0.5 | 6 | 50 | <1 | 12 | 4 | | 1 | <1 |
| (-)13'-0" | 10 | 1.0 | | 3 | 60 | | | 2 | <1 | <1 | |
| (-)14'-0" | | <0.5 | | 2 | 2 | | | 1 | | | |
| (-)15'-0" | | | | 1 | 1 | | | <1 | | | |

Note: Pipe basement is at elevation (-) 7'-0".

18

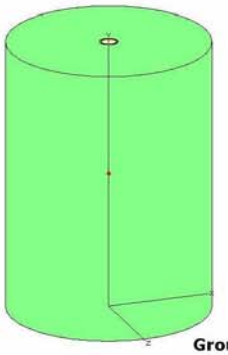
# Appendix D
# MicroShield Run Site 28a

**MicroShield v6.02 (6.02-00063)**
**INEEL**

Page : 1
DOS File : site28a.ms6
Run Date: October 14, 2004
Run Time: 2:12:49 PM
Duration : 00:00:02

File Ref: _____
Date: _____
By: _____
Checked: _____

**Case Title: site28a**
**Description: site28 soil, 1 ft radius, 3 ft long**
**Geometry: 11 - Annular Cylinder - Internal Dose Point**



**Source Dimensions**

| | | |
|---|---|---|
| Height | 91.44 cm | 3 ft |
| Inner Cyl Radius | 2.45 cm | 1.0 in |
| Inner Cyl Thickness | 0.554 cm | 0.2 in |
| Source | 30.48 cm | 1 ft |

**Dose Points**

| | X | Y | Z |
|---|---|---|---|
| # 1 | 0 cm | 45.72 cm | 0 cm |
| | 0.0 in | 1 ft 6.0 in | 0.0 in |

**Shields**

| Shield Name | Dimension | Material | Density |
|---|---|---|---|
| Cyl. Radius | 2.45 cm | Air | 0.00122 |
| Shield 1 | .554 cm | Iron | 7.84 |
| Source | 3.19e+05 cm³ | NBS Concrete | 2 |

**Source Input**
**Grouping Method : Standard Indices**
**Number of Groups : 25**
**Lower Energy Cutoff : 0.015**
**Photons < 0.015 : Included**
**Library : Grove**

| Nuclide | curies | becquerels | µCi/cm³ | Bq/cm³ |
|---|---|---|---|---|
| Ac-225 | 5.3100e-013 | 1.9647e-002 | 1.6620e-012 | 6.1496e-008 |
| Ac-227 | 2.3700e-011 | 8.7690e-001 | 7.4182e-011 | 2.7447e-006 |
| Ac-228 | 7.2900e-016 | 2.6973e-005 | 2.2818e-015 | 8.4426e-011 |
| Ag-108 | 4.6200e-013 | 1.7094e-002 | 1.4461e-012 | 5.3505e-008 |
| Ag-108m | 5.1900e-012 | 1.9203e-001 | 1.6245e-011 | 6.0106e-007 |
| Ag-109m | 1.2000e-011 | 4.4400e-001 | 3.7560e-011 | 1.3897e-006 |
| Ag-110 | 6.5600e-007 | 2.4272e+004 | 2.0533e-006 | 7.5972e-002 |
| Ag-110m | 4.9300e-005 | 1.8241e+006 | 1.5431e-004 | 5.7095e+000 |
| Am-241 | 1.0100e-005 | 3.7370e+005 | 3.1613e-005 | 1.1697e+000 |
| Am-242 | 6.0300e-008 | 2.2311e+003 | 1.8874e-007 | 6.9834e-003 |
| Am-242m | 6.0600e-008 | 2.2422e+003 | 1.8968e-007 | 7.0182e-003 |
| Am-243 | 1.7500e-008 | 6.4750e+002 | 5.4776e-008 | 2.0267e-003 |
| At-217 | 5.0700e-013 | 1.8759e-002 | 1.5869e-012 | 5.8716e-008 |
| Ba-137m | 9.4600e-001 | 3.5002e+010 | 2.9610e+000 | 1.0956e+005 |
| Ba-140 | 4.9600e-015 | 1.8352e-004 | 1.5525e-014 | 5.7442e-010 |
| Be-10 | 3.3000e-011 | 1.2210e+000 | 1.0329e-010 | 3.8218e-006 |
| Bi-208 | 3.5600e-024 | 1.3172e-013 | 1.1143e-023 | 4.1229e-019 |
| Bi-210 | 1.0300e-014 | 3.8110e-004 | 3.2239e-014 | 1.1929e-009 |
| Bi-211 | 2.3200e-011 | 8.5840e-001 | 7.2617e-011 | 2.6868e-006 |
| Bi-212 | 9.6800e-008 | 3.5816e+003 | 3.0299e-007 | 1.1211e-002 |
| Bi-213 | 5.3100e-013 | 1.9647e-002 | 1.6620e-012 | 6.1496e-008 |
| Bi-214 | 2.5800e-013 | 9.5460e-003 | 8.0755e-013 | 2.9879e-008 |
| Bk-249 | 8.9900e-017 | 3.3263e-006 | 2.8139e-016 | 1.0411e-011 |
| C-14 | 1.3300e-009 | 4.9210e+001 | 4.1629e-009 | 1.5403e-004 |
| Cd-109 | 1.2000e-011 | 4.4400e-001 | 3.7560e-011 | 1.3897e-006 |
| Cd-113 | 1.1400e-004 | 4.2180e+006 | 3.5682e-004 | 1.3202e+001 |
| Cd-115m | 2.2800e-007 | 8.4360e+003 | 7.1365e-007 | 2.6405e-002 |
| Ce-141 | 2.1800e-005 | 8.0660e+005 | 6.8235e-005 | 2.5247e+000 |
| Ce-144 | 1.4500e+000 | 5.3650e+010 | 4.5385e+000 | 1.6793e+005 |
| Cf-249 | 6.1500e-017 | 2.2755e-006 | 1.9250e-016 | 7.1224e-012 |

Page : 2
DOS File : site28a.ms6
Run Date: October 14, 2004
Run Time: 2:12:49 PM
Duration : 00:00:02

| Nuclide | curies | becquerels | µCi/cm³ | Bq/cm³ |
|---|---|---|---|---|
| Cf-250 | 1.6400e-016 | 6.0680e-006 | 5.1333e-016 | 1.8993e-011 |
| Cf-251 | 1.0600e-018 | 3.9220e-008 | 3.3178e-018 | 1.2276e-013 |
| Cf-252 | 1.7800e-017 | 6.5860e-007 | 5.5715e-017 | 2.0614e-012 |
| Cm-242 | 1.6300e-007 | 6.0310e+003 | 5.1020e-007 | 1.8877e-002 |
| Cm-243 | 1.5700e-008 | 5.8090e+002 | 4.9142e-008 | 1.8182e-003 |
| Cm-244 | 6.7900e-007 | 2.5123e+004 | 2.1253e-006 | 7.8636e-002 |
| Cm-245 | 4.0700e-011 | 1.5059e+000 | 1.2739e-010 | 4.7135e-006 |
| Cm-246 | 4.3100e-012 | 1.5947e-001 | 1.3490e-011 | 4.9915e-007 |
| Cm-247 | 6.7600e-018 | 2.5012e-007 | 2.1159e-017 | 7.8288e-013 |
| Cm-248 | 9.2600e-018 | 3.4262e-007 | 2.8984e-017 | 1.0724e-012 |
| Cm-250 | 1.8900e-025 | 6.9930e-015 | 5.9158e-025 | 2.1888e-020 |
| Cs-134 | 1.1600e-001 | 4.2920e+009 | 3.6308e-001 | 1.3434e+004 |
| Cs-135 | 6.8600e-006 | 2.5382e+005 | 2.1472e-005 | 7.9446e-001 |
| Cs-136 | 1.7700e-017 | 6.5490e-007 | 5.5402e-017 | 2.0499e-012 |
| Cs-137 | 1.0000e+000 | 3.7000e+010 | 3.1300e+000 | 1.1581e+005 |
| Eu-152 | 9.6500e-005 | 3.5705e+006 | 3.0205e-004 | 1.1176e+001 |
| Eu-154 | 2.7600e-002 | 1.0212e+009 | 8.6389e-002 | 3.1964e+003 |
| Eu-155 | 1.2900e-002 | 4.7730e+008 | 4.0377e-002 | 1.4940e+003 |
| Eu-156 | 9.2800e-015 | 3.4336e-004 | 2.9047e-014 | 1.0747e-009 |
| Fr-221 | 5.3100e-013 | 1.9647e-002 | 1.6620e-012 | 6.1496e-008 |
| Fr-223 | 3.2800e-013 | 1.2136e-002 | 1.0267e-012 | 3.7986e-008 |
| Gd-152 | 1.6800e-017 | 6.2160e-007 | 5.2585e-017 | 1.9456e-012 |
| Gd-153 | 6.9200e-007 | 2.5604e+004 | 2.1660e-006 | 8.0141e-002 |
| H-3 | 4.0000e-004 | 1.4800e+007 | 1.2520e-003 | 4.6324e+001 |
| Ho-166 | 5.4100e-010 | 2.0017e+001 | 1.6933e-009 | 6.2654e-005 |
| I-129 | 2.2000e-007 | 8.1400e+003 | 6.8861e-007 | 2.5478e-002 |
| In-114 | 1.2600e-012 | 4.6620e-002 | 3.9438e-012 | 1.4592e-007 |
| In-114m | 1.3200e-012 | 4.8840e-002 | 4.1316e-012 | 1.5287e-007 |
| In-115 | 7.6400e-017 | 2.8268e-006 | 2.3913e-016 | 8.8480e-012 |
| In-115m | 1.6000e-011 | 5.9200e-001 | 5.0081e-011 | 1.8530e-006 |
| La-140 | 5.7100e-015 | 2.1127e-004 | 1.7872e-014 | 6.6128e-010 |
| Nb-93m | 7.5600e-006 | 2.7972e+005 | 2.3663e-005 | 8.7553e-001 |
| Nb-94 | 2.4700e-010 | 9.1390e+000 | 7.7312e-010 | 2.8605e-005 |
| Nb-95 | 4.4100e-002 | 1.6317e+009 | 1.3803e-001 | 5.1073e+003 |
| Nb-95m | 1.4800e-004 | 5.4760e+006 | 4.6324e-004 | 1.7140e+001 |
| Nd-147 | 5.2400e-018 | 1.9388e-007 | 1.6401e-017 | 6.0685e-013 |
| Np-235 | 7.7900e-010 | 2.8823e+001 | 2.4383e-009 | 9.0217e-005 |
| Np-237 | 3.2600e-006 | 1.2062e+005 | 1.0204e-005 | 3.7754e-001 |
| Np-238 | 3.0300e-010 | 1.1211e+001 | 9.4840e-010 | 3.5091e-005 |
| Np-239 | 1.7500e-008 | 6.4750e+002 | 5.4776e-008 | 2.0267e-003 |
| Np-240 | 3.0700e-016 | 1.1359e-005 | 9.6092e-016 | 3.5554e-011 |
| Pa-231 | 1.7100e-010 | 6.3270e+000 | 5.3524e-010 | 1.9804e-005 |
| Pa-233 | 3.2600e-006 | 1.2062e+005 | 1.0204e-005 | 3.7754e-001 |
| Pa-234 | 1.4000e-011 | 5.1800e-001 | 4.3820e-011 | 1.6214e-006 |
| Pa-234m | 1.0800e-008 | 3.9960e+002 | 3.3804e-008 | 1.2508e-003 |
| Pb-209 | 5.3100e-013 | 1.9647e-002 | 1.6620e-012 | 6.1496e-008 |
| Pb-210 | 1.0500e-014 | 3.8850e-004 | 3.2865e-014 | 1.2160e-009 |
| Pb-211 | 2.3200e-011 | 8.5840e-001 | 7.2617e-011 | 2.6868e-006 |
| Pb-212 | 9.6800e-008 | 3.5816e+003 | 3.0299e-007 | 1.1211e-002 |
| Pb-214 | 2.5800e-013 | 9.5460e-003 | 8.0755e-013 | 2.9879e-008 |
| Pd-107 | 1.7300e-007 | 6.4010e+003 | 5.4150e-007 | 2.0035e-002 |
| Pm-146 | 6.5500e-006 | 2.4235e+005 | 2.0502e-005 | 7.5856e-001 |
| Pm-147 | 7.6400e-001 | 2.8268e+010 | 2.3913e+000 | 8.8480e+004 |
| Pm-148 | 5.0700e-008 | 1.8759e+003 | 1.5869e-007 | 5.8716e-003 |
| Pm-148m | 9.0000e-007 | 3.3300e+004 | 2.8170e-006 | 1.0423e-001 |
| Po-210 | 7.9300e-015 | 2.9341e-004 | 2.4821e-014 | 9.1838e-010 |
| Po-211 | 6.2000e-014 | 2.2940e-003 | 1.9406e-013 | 7.1803e-009 |
| Po-212 | 6.0900e-008 | 2.2533e+003 | 1.9062e-007 | 7.0529e-003 |
| Po-215 | 2.2100e-011 | 8.1770e-001 | 6.9174e-011 | 2.5594e-006 |
| Po-216 | 9.6800e-008 | 3.5816e+003 | 3.0299e-007 | 1.1211e-002 |

Appendix D

Page : 3
DOS File : site28a.ms6
Run Date: October 14, 2004
Run Time: 2:12:49 PM
Duration : 00:00:02

| Nuclide | curies | becquerels | µCi/cm³ | Bq/cm³ |
|---|---|---|---|---|
| Po-218 | 2.5800e-013 | 9.5460e-003 | 8.0755e-013 | 2.9879e-008 |
| Pr-143 | 4.3300e-014 | 1.6021e-003 | 1.3553e-013 | 5.0146e-009 |
| Pr-144 | 1.4500e+000 | 5.3650e+010 | 4.5385e+000 | 1.6793e+005 |
| Pr-144m | 1.7300e-002 | 6.4010e+008 | 5.4150e-002 | 2.0035e+003 |
| Pu-236 | 4.7200e-007 | 1.7464e+004 | 1.4774e-006 | 5.4663e-002 |
| Pu-237 | 2.0600e-012 | 7.6220e-002 | 6.4479e-012 | 2.3857e-007 |
| Pu-238 | 1.1800e-002 | 4.3660e+008 | 3.6934e-002 | 1.3666e+003 |
| Pu-239 | 4.2800e-005 | 1.5836e+006 | 1.3397e-004 | 4.9567e+000 |
| Pu-240 | 1.4600e-005 | 5.4020e+005 | 4.5698e-005 | 1.6908e+000 |
| Pu-241 | 1.6800e-003 | 6.2160e+007 | 5.2585e-003 | 1.9456e+002 |
| Pu-242 | 4.8800e-009 | 1.8056e+002 | 1.5275e-008 | 5.6516e-004 |
| Pu-243 | 6.7500e-018 | 2.4975e-007 | 2.1128e-017 | 7.8173e-013 |
| Pu-244 | 3.0800e-016 | 1.1396e-005 | 9.6405e-016 | 3.5670e-011 |
| Ra-223 | 2.3200e-011 | 8.5840e-001 | 7.2617e-011 | 2.6868e-006 |
| Ra-224 | 9.6800e-008 | 3.5816e+003 | 3.0299e-007 | 1.1211e-002 |
| Ra-225 | 5.3200e-013 | 1.9684e-002 | 1.6652e-012 | 6.1612e-008 |
| Ra-226 | 2.6200e-013 | 9.6940e-003 | 8.2007e-013 | 3.0343e-008 |
| Ra-228 | 7.2900e-016 | 2.6973e-005 | 2.2818e-015 | 8.4426e-011 |
| Rb-86 | 5.9100e-014 | 2.1867e-003 | 1.8498e-013 | 6.8444e-009 |
| Rb-87 | 3.2200e-010 | 1.1914e+001 | 1.0079e-009 | 3.7291e-005 |
| Rh-103m | 1.1600e-004 | 4.2920e+006 | 3.6308e-004 | 1.3434e+001 |
| Rh-106 | 1.3200e-001 | 4.8840e+009 | 4.1316e-001 | 1.5287e+004 |
| Rn-219 | 2.3200e-011 | 8.5840e-001 | 7.2617e-011 | 2.6868e-006 |
| Rn-220 | 9.6800e-008 | 3.5816e+003 | 3.0299e-007 | 1.1211e-002 |
| Rn-222 | 2.5800e-013 | 9.5460e-003 | 8.0755e-013 | 2.9879e-008 |
| Ru-103 | 1.2900e-004 | 4.7730e+006 | 4.0377e-004 | 1.4940e+001 |
| Ru-106 | 1.3200e-001 | 4.8840e+009 | 4.1316e-001 | 1.5287e+004 |
| Sb-124 | 4.2000e-007 | 1.5540e+004 | 1.3146e-006 | 4.8641e-002 |
| Sb-125 | 1.7100e-002 | 6.3270e+008 | 5.3524e-002 | 1.9804e+003 |
| Sb-126 | 5.9500e-007 | 2.2015e+004 | 1.8624e-006 | 6.8908e-002 |
| Sb-126m | 4.2500e-006 | 1.5725e+005 | 1.3303e-005 | 4.9220e-001 |
| Se-79 | 4.7900e-006 | 1.7723e+005 | 1.4993e-005 | 5.5474e-001 |
| Sm-147 | 6.1800e-011 | 2.2866e+000 | 1.9344e-010 | 7.1571e-006 |
| Sm-151 | 4.6100e-003 | 1.7057e+008 | 1.4429e-002 | 5.3389e+002 |
| Sn-119m | 5.9200e-005 | 2.1904e+006 | 1.8530e-004 | 6.8560e+000 |
| Sn-123 | 4.1700e-004 | 1.5429e+007 | 1.3052e-003 | 4.8293e+001 |
| Sn-126 | 4.2500e-006 | 1.5725e+005 | 1.3303e-005 | 4.9220e-001 |
| Sr-89 | 2.4300e-003 | 8.9910e+007 | 7.6060e-003 | 2.8142e+002 |
| Sr-90 | 9.5900e-001 | 3.5483e+010 | 3.0017e+000 | 1.1106e+005 |
| Tb-160 | 2.4200e-007 | 8.9540e+003 | 7.5747e-007 | 2.8026e-002 |
| Tc-98 | 2.6400e-011 | 9.7680e-001 | 8.2633e-011 | 3.0574e-006 |
| Tc-99 | 1.5600e-004 | 5.7720e+006 | 4.8829e-004 | 1.8067e+001 |
| Te-123 | 4.6500e-018 | 1.7205e-007 | 1.4555e-017 | 5.3852e-013 |
| Te-123m | 6.3100e-009 | 2.3347e+002 | 1.9751e-008 | 7.3077e-004 |
| Te-125m | 4.1800e-003 | 1.5466e+008 | 1.3084e-002 | 4.8409e+002 |
| Te-127 | 9.7500e-004 | 3.6075e+007 | 3.0518e-003 | 1.1292e+002 |
| Te-127m | 9.9500e-004 | 3.6815e+007 | 3.1144e-003 | 1.1523e+002 |
| Te-129 | 3.8800e-007 | 1.4356e+004 | 1.2145e-006 | 4.4935e-002 |
| Te-129m | 5.9600e-007 | 2.2052e+004 | 1.8655e-006 | 6.9023e-002 |
| Th-227 | 2.3100e-011 | 8.5470e-001 | 7.2304e-011 | 2.6752e-006 |
| Th-228 | 9.6300e-008 | 3.5631e+003 | 3.0142e-007 | 1.1153e-002 |
| Th-229 | 5.3300e-013 | 1.9721e-002 | 1.6683e-012 | 6.1727e-008 |
| Th-230 | 5.7100e-010 | 2.1127e+001 | 1.7872e-009 | 6.6128e-005 |
| Th-231 | 1.3700e-006 | 5.0690e+004 | 4.2881e-006 | 1.5866e-001 |
| Th-232 | 2.0700e-015 | 7.6590e-005 | 6.4792e-015 | 2.3973e-010 |
| Th-234 | 1.0800e-008 | 3.9960e+002 | 3.3804e-008 | 1.2508e-003 |
| Tl-207 | 2.3100e-011 | 8.5470e-001 | 7.2304e-011 | 2.6752e-006 |
| Tl-208 | 3.4800e-008 | 1.2876e+003 | 1.0893e-007 | 4.0302e-003 |
| Tl-209 | 1.1500e-014 | 4.2550e-004 | 3.5995e-014 | 1.3318e-009 |
| Tm-170 | 7.1800e-013 | 2.6566e-002 | 2.2474e-012 | 8.3152e-008 |

Appendix D

Page : 4
DOS File : site28a.ms6
Run Date: October 14, 2004
Run Time: 2:12:49 PM
Duration : 00:00:02

| Nuclide | curies | becquerels | µCi/cm³ | Bq/cm³ |
|---|---|---|---|---|
| Tm-171 | 3.3200e-012 | 1.2284e-001 | 1.0392e-011 | 3.8449e-007 |
| U-232 | 1.1900e-011 | 4.4030e-001 | 3.7247e-011 | 1.3782e-006 |
| U-233 | 2.5700e-014 | 9.5090e-004 | 8.0442e-014 | 2.9763e-009 |
| U-234 | 3.1500e-009 | 1.1655e+002 | 9.8596e-009 | 3.6481e-004 |
| U-235 | 1.3700e-010 | 5.0690e+000 | 4.2881e-010 | 1.5866e-005 |
| U-236 | 5.3500e-010 | 1.9795e+001 | 1.6746e-009 | 6.1959e-005 |
| U-237 | 4.1200e-012 | 1.5244e-001 | 1.2896e-011 | 4.7714e-007 |
| U-238 | 1.0800e-012 | 3.9960e-002 | 3.3804e-012 | 1.2508e-007 |
| U-240 | 3.0700e-020 | 1.1359e-009 | 9.6092e-020 | 3.5554e-015 |
| Y-90 | 9.5900e-001 | 3.5483e+010 | 3.0017e+000 | 1.1106e+005 |
| Y-91 | 9.7500e-003 | 3.6075e+008 | 3.0518e-002 | 1.1292e+003 |
| Zr-93 | 2.4600e-005 | 9.1020e+005 | 7.6999e-005 | 2.8490e+000 |
| Zr-95 | 1.9900e-002 | 7.3630e+008 | 6.2288e-002 | 2.3046e+003 |

**Buildup**
**The material reference is : Source**

**Integration Parameters**

| | |
|---|---|
| Radial | 10 |
| Circumferential | 10 |
| Y Direction (axial) | 20 |

**Results**

| Energy MeV | Activity photons/sec | Fluence Rate MeV/cm²/sec No Buildup | Fluence Rate MeV/cm²/sec With Buildup | Exposure Rate mR/hr No Buildup | Exposure Rate mR/hr With Buildup |
|---|---|---|---|---|---|
| 0.015 | 3.253e+06 | 9.238e-113 | 5.546e-26 | 7.923e-114 | 4.757e-27 |
| 0.02 | 1.423e+06 | 1.161e-51 | 4.258e-26 | 4.021e-53 | 1.475e-27 |
| 0.03 | 2.716e+09 | 3.044e-14 | 8.717e-14 | 3.017e-16 | 8.639e-16 |
| 0.04 | 5.820e+09 | 5.811e-05 | 2.954e-04 | 2.570e-07 | 1.306e-06 |
| 0.05 | 8.149e+07 | 2.187e-03 | 1.691e-02 | 5.826e-06 | 4.505e-05 |
| 0.06 | 7.831e+07 | 9.253e-02 | 8.830e-01 | 1.838e-04 | 1.754e-03 |
| 0.08 | 1.006e+09 | 3.436e+01 | 3.348e+02 | 5.438e-02 | 5.299e-01 |
| 0.1 | 5.159e+08 | 7.284e+01 | 6.279e+02 | 1.114e-01 | 9.606e-01 |
| 0.15 | 5.796e+09 | 3.414e+03 | 2.213e+04 | 5.623e+00 | 3.644e+01 |
| 0.2 | 1.194e+08 | 1.333e+02 | 7.239e+02 | 2.352e-01 | 1.278e+00 |
| 0.3 | 5.206e+06 | 1.209e+01 | 5.278e+01 | 2.294e-02 | 1.001e-01 |
| 0.4 | 2.067e+08 | 7.769e+02 | 2.935e+03 | 1.514e+00 | 5.719e+00 |
| 0.5 | 1.141e+09 | 6.184e+03 | 2.094e+04 | 1.214e+01 | 4.111e+01 |
| 0.6 | 3.833e+10 | 2.797e+05 | 8.676e+05 | 5.460e+02 | 1.693e+03 |
| 0.8 | 6.819e+09 | 7.962e+04 | 2.167e+05 | 1.514e+02 | 4.121e+02 |
| 1.0 | 5.525e+08 | 9.292e+03 | 2.295e+04 | 1.713e+01 | 4.230e+01 |
| 1.5 | 7.277e+08 | 2.368e+04 | 4.978e+04 | 3.984e+01 | 8.376e+01 |
| 2.0 | 4.153e+08 | 2.130e+04 | 4.068e+04 | 3.294e+01 | 6.291e+01 |
| 3.0 | 1.285e+03 | 1.217e-01 | 2.063e-01 | 1.651e-04 | 2.798e-04 |
| TOTALS: | 6.433e+10 | 4.243e+05 | 1.245e+06 | 8.071e+02 | 2.381e+03 |

Bechtel BWXT Idaho, LLC

INTEROFFICE MEMORANDUM

**Date:** February 15, 2005

**To:** L. S. Cahn MS 3419 6-3080

**From:** M. C. Swenson MS 3404 6-3576

**Subject:** CONCENTRATION OF HG, CR, AND AS IN WASTES RELEASED TO THE SOIL IN SELECTED TANK FARM CONTAMINATION SITES

References:
(a) M. D. Staiger and M. C. Swenson, Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center, INEEL/EXT-98-00455, Rev 2, January 2005
(b) W. J. Bjorklund et al., First Electrolytic Dissolution Campaign of EBR-II Fuel at ICPP, ICP-1028, February 1974

Per your request, this report documents the concentrations of three metals, mercury (Hg), chromium (Cr) and arsenic (As), in the wastes whose releases resulted in the largest amounts of soil contamination in the Tank Farm. The wastes were released at contamination sites CPP-31, CPP-28, CPP-79 (deep), and CPP-27/33. There were several other waste releases in the Tank Farm area, however the total amount of Hg and Cr in other releases was negligible (<1%) compared to the four largest releases. In many cases the volume of waste released at other sites was negligible (several releases were less than 1 gallon compared to the CPP-31 release of nearly 19,000 gallons). Those sites with relatively large release volumes (such as those involving Evaporator condensate and service waste water) had very low levels of the contaminants of concern. The concentrations of the requested metals in the wastes that contaminated those sites are shown in Table 1. A discussion of the source of the Table 1 data follows.

**Table 1.** Concentrations of Hg, Cr, and As in wastes responsible for the major Tank Farm contamination sites.

| Tank Farm Contamination Site | Hg (mg/L) | Cr (mg/L) | As (mg/L) |
|---|---|---|---|
| CPP-31 | 996 | 182 | 0.06* |
| CPP-28 | 595 | 398 | <1 |
| CPP-27/33 | 702 | 24 | <1 |
| CPP-79 (deep) | 202 | 943 | <1 |

*The As concentration in INTEC wastes was generally below laboratory detection values. This value, though reported, may have also been a “less than” laboratory detection value.

The data in Table 1 include both waste sample analyses and process knowledge-based estimates. Mercury and chromium were routinely used in known concentrations in the historical fuel dissolution and uranium extraction processes. Mercuric nitrate was used as a catalyst in the dissolution of aluminum-clad fuel. Chromic oxide was used as an oxidant in the dissolution process. Chromium was also a component of some of the aluminum, stainless steel, and zirconium alloys used as fuel cladding. Analytical data for mercury are available for many wastes; data for chromium are available for a few

wastes. However, both can be accurately estimated using historical fuel reprocessing flowsheets (recipes and material balances) for those wastes for which no analytical data for those species exist. Accurate chemical composition estimates can be made because the fuel reprocessing chemistry was a well documented process that required tight constraints on chemical compositions to safely and effectively dissolve fuel and recover uranium.

Arsenic was not used in any of the fuel reprocessing or waste treatment systems, nor was it a constituent of the fuel cladding alloys. Several types of Tank Farm waste were analyzed for arsenic in the early 1990s as part of a RCRA waste characterization effort. Arsenic was generally not detected in Tank Farm wastes. The laboratory detection level for As in Tank Farm wastes was generally 1 to 4 mg/L. There were a few analyses for some Tank Farm wastes in which As was detected at approximately 0.1 mg/L. It is not clear if those were actual As concentrations, or if the laboratory validation flags were omitted and those analyses were also less than laboratory detection limits. Historical samples of other (non Tank Farm) INTEC wastes have also generally contained no detectable As. Those that contained detectable As had only a few parts per billion. Due to the general lack of repeatable, detectable amounts of As in Tank Farm wastes and because As was not used in the INTEC fuel and waste processes, As should not be considered a contaminant of potential concern in the Tank Farm wastes that leaked to the soil.

Site CPP-31 is by far the largest of the Tank Farm contamination sites (in radioactivity, most chemicals, and volume of waste released). Site CPP-31 is the result of a piping leak during a waste transfer of sodium-bearing waste from WM-181 to WM-180 in November 1972. The data for CPP-31 in Table 1 came from waste sample analyses. The Hg concentration came from a sample of the WM-181 waste taken shortly before the waste transfer to WM-180 occurred[a]. The Cr concentration came from a WM-180 waste sample after the transfer occurred[b]. The As concentration came from a sample of WM-185 waste after the WM-180 waste (originally in WM-181) was concentrated in the WC-114 evaporator and the concentrate was sent to WM-185[c]. The WM-185 sample result was adjusted (60%) to account for the waste concentration in the Evaporator and to reflect the original WM-181 composition.

The CPP-28 contamination site is the result of a leak of first-cycle coprocessing waste from a waste transfer pipe in 1974. WM-188 was filled with the 1974 coprocessing waste. The WM-188 waste was sampled and some of it was calcined in 1979. It was sampled again and the remainder of the waste was calcined 1983. The Hg (waste sample data) and Cr (flowsheet-based estimate) content of the 1974 coprocessing waste are documented in Reference (a) (from feed streams 66 and 51 respectively). The As concentration in Table 1 (non-detect) was typical for first-cycle waste determined by the early 1990s sampling effort, as previously discussed.

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[a] WM-181 waste sample log 71-7455.

[b] WM-180 waste sample log 83-060324.

[c] WM-185 waste sample logs 90-09042, 90-09053, 90-09069, 91-061219, and 91-08047.

The CPP-27/33 contamination came from leaks of waste sent from the Waste Calcining Facility (WCF) to the PEW Evaporator. Some of that waste backed up a drain line into a carbon-steel Tank Farm pressure relief line that corroded and released the waste to the soil. The WCF waste was composed of both dilute decontamination solution and concentrated off-gas scrub solution. The scrub solution was normally recycled back to the WCF feed system during Calciner operation. However, during WCF Campaigns 1 and 2, a large volume (200,000 gallons) of scrub solution was sent to the PEW Evaporator due to recycle system valve failures at the WCF. The concentrated scrub solution contained the bulk of both the radioactivity and metals released to the soil at CPP-27/33. The scrub solution leaks occurred during an approximate 3-year period during WCF Campaigns 1 and 2, however, it is uncertain exactly when the leaks occurred during that period.

The values for Hg and Cr in CPP-27/33 in Table 1 are one-fourth of the average WCF feed composition during Campaigns 1 and 2 (feed streams 1 through 15 excluding streams 3, 5, and 14 from Reference (a). Feed streams 3 and 5 were excluded because they were too small to have affected the scrub solution composition, and stream 15 was Zr waste whose high fluoride scrub solution was not sent to the PEW Evaporator. The factor of one-fourth was the average ratio of WCF scrub solution component concentrations compared to that of the feed solution during that time. The Hg is based upon historical waste sample analyses and the Cr is estimated from fuel reprocessing flowsheets. The Hg content of the WCF feed solution (and consequently the waste released at CPP-27) did not change significantly during the scrub solution leak time. However, the Cr content of the waste changed significantly, depending on the source of the waste that was calcined. The Cr content could be a factor of about 2 times higher or one tenth the value on Table 1, depending on which waste was calcined at the time of the leak.

The CPP-79 deep contamination is the result of leaks from flanged piping connections that had inadequate secondary containment (split tile pipe). The waste that leaked came from several sources, but the composition of the waste in Table 1 is the average of all sources. The primary source was first-cycle waste from stainless-steel-clad fuels, with smaller amounts of first-cycle wastes from aluminum and zirconium clad fuels, and some second-cycle wastes. A radiological source term for the waste was developed using the Pu-238 and Pu-239/240 ratios in the CPP-79 soil sample from the 56-60 foot below grade elevation. The Pu ratios differ significantly between different types of fuel and can be used to develop a source term. The CPP-79 radiological source term corresponds to a volumetric mixture of 66% first-cycle stainless steel and 34% first-cycle coprocessing wastes. The Hg and Cr concentrations in Table 1 were estimated using the same waste mixture as the radiological source term. This includes 34% of the Hg and Cr concentrations in the CPP-28 (coprocessing waste) source term in Table 1, and 66% of the Hg and Cr concentrations in the first-cycle waste (IAR) in the stainless-steel fuel reprocessing flowsheet (material balance) in Figure 4 of Reference (b). The flowsheet value for Hg in stainless-steel waste was 0 mg/L (Hg was not used in the early stainless-steel fuel reprocessing system). The flowsheet value for Cr in stainless-steel waste was 1224 mg/L (18% of the 6.8 g/L of stainless steel in the waste). The As concentration in Table 1 (non-detect) was typical for first-cycle waste determined by the early 1990s sampling effort, as previously discussed.

If you have questions, please call me.

MCS:rrh

cc: J. R. Forbes, MS 3419
D. F. Nickelson, MS 3670
P. Martian, MS 2107
M. W. Patterson, MS 3404
J. I. Pruitt, MS 3404
M. D. Staiger, MS 3404
F. S. Ward, MS 5111
SP3 CFL/S. A. Gibson, MS 3106
M. C. Swenson Letter File (MCS-02-05)

Uniform File Code: 6150
Disposition Authority: ENV1-k-2-b
Retention Schedule: Cutoff at project completion, cancellation, or termination or in 5 year blocks. Destroy 25 years after project completion.

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Bechtel BWXT Idaho, LLC

INTEROFFICE MEMORANDUM

**Date:** February 24, 2005

**To:** L. S. Cahn MS 3419 6-3080

**From:** M. C. Swenson MS 3404 6-3576

**Subject:** CAUSES, COMPOSITIONS, AND VOLUMES OF WASTE RELEASED AT THE INTEC TANK FARM IN CONTAMINATION SITES CPP-15 AND -79/28 (DEEP)

Attached is a detailed report of the soil contamination in sites CPP-15 and -79 deep. The report includes the causes of the soil contamination, estimates of the amount of waste that leaked to the soil, and a source term for each of the wastes. The source term concentrates on Cs-137, Sr-90, I-129, Tc-99, H-3, and nitrate for the purpose of developing a model of the contamination movement through the INTEC soils. Contamination site CPP-79 has been divided into two sections, arbitrarily called shallow and deep due to their location within the soil. A previous report (MCS-07-04) discussed the contamination relative to the CPP-79 shallow site. This report covers the CPP-79 deep portion of that site.

If you have questions, please contact me.

MCS:rrh

Attachment

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